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INSTITUTE FOR DEFENSE ANALYSES

Trends in Weapon System Operating and Support Costs

Timothy J. Graves, Project Leader
Joseph S. Domin
Ronald E. Porten

October 1997

IDA Paper P-3313
Log: H 97-001180

This work was conducted under contract DASW01 94 C 0054, Task T-G7-838, for the Office of the Director, Acquisition Program Integration. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Under Secretary of Defense (Acquisition and Technology) under a task entitled "Trends in Weapon System O&S." The objective of the task was to determine if past efforts to reduce operating and support (O&S) costs have been effective.

This paper is compilation of material from multiple briefings presented to the sponsor's advisor panel over a period of 15 months.

This work was reviewed within IDA by William L. Greer, Bruce N. Angier, David A. Drake, and James L. Wilson.

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EXECUTIVE SUMMARY

In this period of diminishing Department of Defense (DoD) budgets, an increasing percentage of each budget goes to the operating and support (O&S) accounts. This slows modernization of weapons inventories and could cause the average age of weapon systems in use to rise, perhaps to unacceptable levels. To address this situation, decision makers must buy fewer or less expensive replacement systems and find ways to lower the O&S costs of existing and future systems. Concerned about the effect of shrinking modernization budgets, the Under Secretary of Defense for Acquisition and Technology recently asked the Service Acquisition Executives to look for acceptable ways to minimize O&S requirements for systems now under development. He also asked that a study be undertaken to determine if past efforts to reduce O&S costs have been effective. This study responds to that tasking.

DoD's efforts to reduce per unit weapon system O&S costs have not been fully successful. In half of the cases we studied, the new weapons were more expensive to operate and in half they were the same or less expensive. Figure S-1 shows the percentage increase or decrease between each new system we studied and its predecessor for both annual O&S cost and O&S cost per hour or mile.

However, Figure S-1 does not tell the whole story. Most new weapon systems are more complex, more expensive to buy, and have significantly more capability than their predecessors. The cost of buying a new system, i.e., its asset value, is a rough measure of its sophistication and complexity. When you take asset value and capability into account, new systems are often less expensive to operate than the systems they replaced. Said another way, the new system gives you more capability for your operating dollar than the weapon it replaced. Also, when you consider the increased capability of a new weapon, the total operating cost of a replacement fleet may decline because fewer weapons can do the same job.[1] Figure S-2 presents O&S costs per unit of capability and O&S costs per thousand dollars of asset value.[2]

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1 However, no savings can be claimed if deployment needs preclude reducing fleet size.

2 Capability calculations were done using the TASCFORM scoring system. TASCFORM is a product of The Analytic Sciences Corporation (TASC). The study sponsor approved the use of TASCFORM as the measure of capability, where appropriate, for this study.

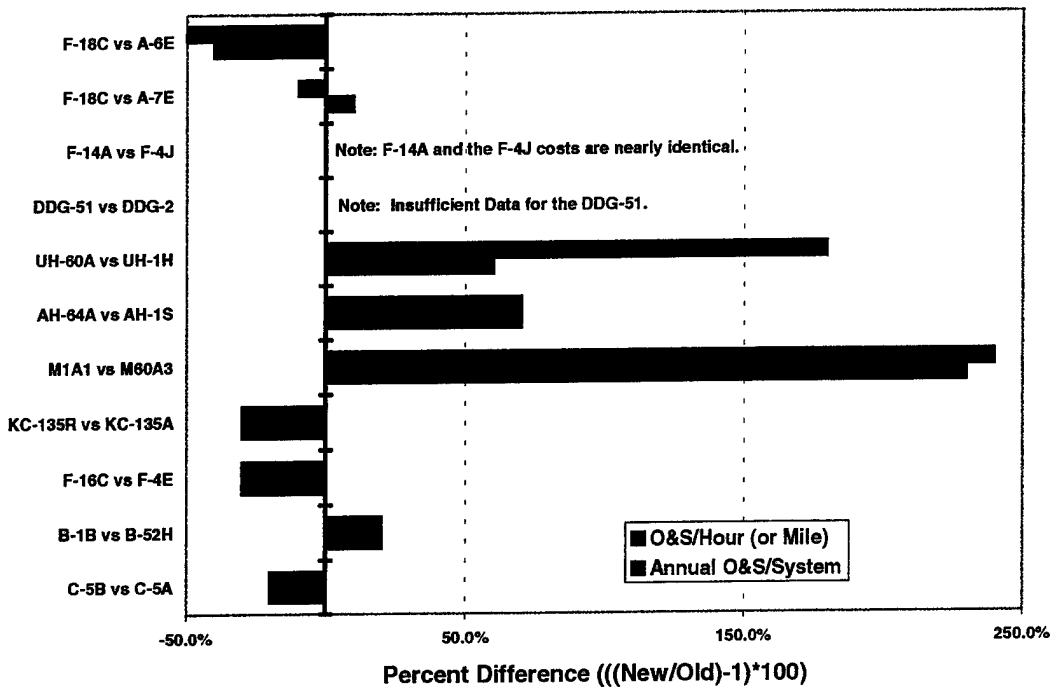

Figure S-1. O&S Costs Per Hour or Mile and O&S Costs Per Year (Percent Difference in O&S Costs as a Ratio of New Systems to Old Systems)

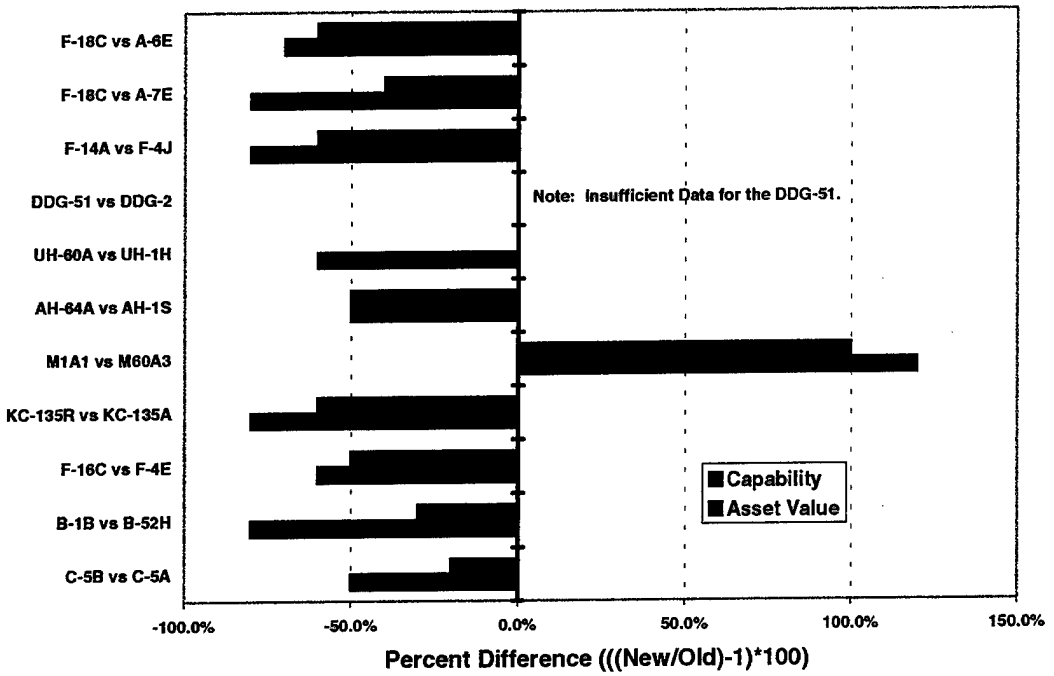

Figure S-2. O&S Costs Per Unit of Capability and O&S Costs Per Thousand Dollars of Asset Value (Percent Difference in O&S Costs as a Ratio of New Systems to Old Systems)

We have not addressed potential O&S cost increases avoided through cost-reducing design initiatives or improvements to components with low mean-time-between-failure (MTBF) records. We simply have no way of determining how much more a new weapon system might have cost to operate if cost-reducing initiatives were not pursued.

In addition to comparing new to old individual systems, we tallied the costs for groups of weapons that might be available to pursue similar tasks within the same overall mission area. Mission area costs are affected by changes in weapon inventory level in addition to weapon characteristics and activity level. To get a sense of the overall effect of modernization on DoD O&S spending, we studied six mission areas in the Navy and Air Force.[3] We prepared calculations similar to those used in the weapon system case studies for each of these mission areas. Figure S-3 provides percentage increase or decrease in the average O&S cost per flying or steaming hour and the average annual O&S cost per system.

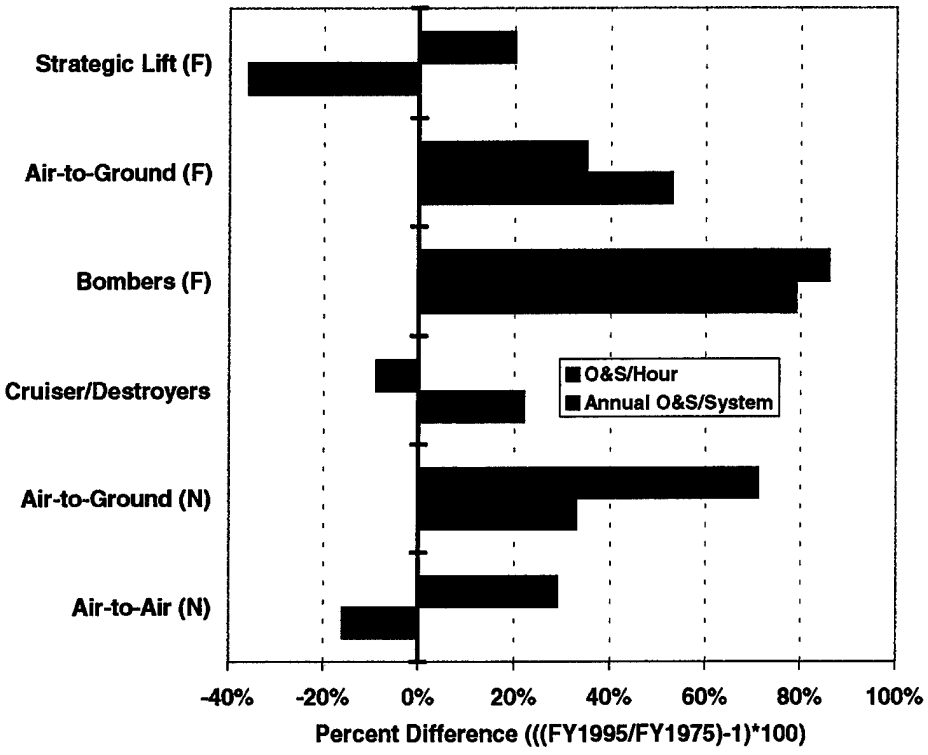

Figure S-3. Average O&S Costs Per Hour or Mile and Average O&S Costs Per Year (Percent Difference In O&S Costs as a Ratio of FY 1995 Costs to FY 1975 Costs)

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3 A major source of data for these studies was the Future Years Defense Program (FYDP). The structure of the Army data in the FYDP does not permit dividing the Army's overall mission into sub-missions suitable for this study.

These data reflect more than the effects of modernization per se. Other management actions such as the reduction of flying or steaming hours can be seen in some areas. In the Navy air-to-air mission, for example, the average cost per flying hour rose relative to FY 1975, but the annual O&S cost per system declined. In the Air Force air-to-ground mission, O&S per flying hour and per system both increased, but O&S per flying hour increased less than O&S per system.

We also computed the percentage increase or decrease in the asset value of the weapons in each mission area and again calculated the changes in their capability using the TASCFORM scoring system. Figure S-4 shows the results of those calculations.

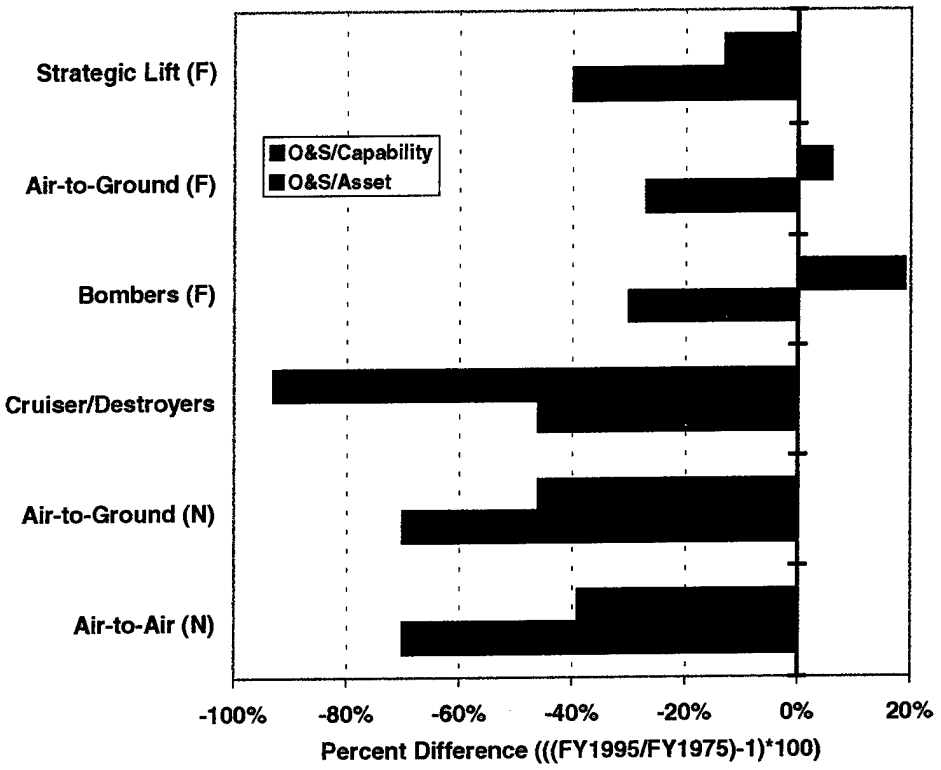

Figure S-4. Average O&S Costs Per Unit of Capability and Average O&S Costs Per Thousand Dollars of Asset Value (Percent Difference in O&S Costs as a Ratio of FY 1995 Costs to FY 1975 Costs)

Notice that the O&S per unit of capability for cruisers and destroyers shown in Figure S-4 has a more substantial drop than O&S per thousand dollars of asset value. A very high-capability increase generated by the introduction of the AEGIS system and vertical launch capability on the DDG-51 is responsible for much of that decrease.

Although we were able to establish the average age of force elements in each time period, the effects of age on O&S costs were not discernable in our analysis. Much of the reason is the limitations of our two principal data sources. FYDP data goes back to FY 1962, but is too highly aggregated to permit a view of O&S costs for an individual system over an extended period of time. A 20- to 30-year tracking of O&S costs is needed to view the entire life cycle for most weapon systems. The Services' Visibility and Management of Operating and Support Costs (VAMOSC) databases allow a view of individual system O&S costs, but a consistent set of data is available only from around FY 1987 to FY 1995, and age effects were not visible in this data set.

Our assessments discuss funding changes only in terms of inventory and activity levels and do not explicitly evaluate them in terms of subtle changes in policy. For example, in many of our comparisons we observe that from FY 1975 to 1995, military personnel funding has decreased substantially while Operations and Maintenance (O&M) has decreased by a much smaller percentage or has actually increased. We feel strongly that, in addition to changes in inventory and activity levels, this effect is influenced by program content and policy changes, such as contracting manpower, privatization, and outsourcing. One of these changes is that a substantial amount of work now done in depot maintenance by civilian personnel used to be done in intermediate maintenance by military personnel. This shift in maintenance activity may be the result of continually acquiring ever-higher technology weapons. The emphasis on high-tech weapons requires a maintenance workforce that can constantly increase its high-tech skills; a workforce that can perhaps be developed and maintained more efficiently in the civilian workforce now found in depots. To mitigate effects caused by the shift of work from the military to a civilian workforce, we have used O&S changes rather than O&M changes wherever possible in this study.

I. INTRODUCTION

A. BACKGROUND

1. Force Structure Down; O&M Up

In 1994, IDA studied the growth of Operations and Maintenance (O&M) funding to discover why O&M funding requirements are increasing in the DoD while the force structure is declining.[1] Table I-1 from that study summarizes the differences found in Future Years Defense Program (FYDP) data for fiscal years (FY) 1975 and 1995.

Table I-1. Changes in Forces, Manpower, and O&M Funding

	FY 1975	FY 1995	Percentage Change
Forces			
Aircraft Carriers	16	12	-25.0%
Cruisers and Destroyers	129	80	-38.0%
Frigates	64	49	-23.4%
Submarines	118	100	-15.3%
Bomber Aircraft	414	116	-72.0%
Fighter/Attack Aircraft	4,258	3,730	-12.4%
Antisubmarine Warfare Aircraft	156	98	-37.2%
Patrol Aircraft	316	234	-25.9%
Divisions	25	16	-36.0%
Manpower			
Active-Duty Military Personnel	2,127,293	1,498,646	-29.6%
Civilians	1,091,669	893,910	-18.1%
O&M Funding			
FY95 $M	$70,383	$92,862	31.9%

[1] The findings are shown in an IDA document by Timothy J. Graves and Joseph S. Domin, "Understanding Increased Operations and Maintenance (O&M) Funding Requirements: A Comparison of FY 1975 and FY 1995 O&M Programs," Institute for Defense Analyses, Document D-1616, December 1994.

The dramatic decline in force levels and the equally dramatic increase in O&M funding seem to be inconsistent. This anomaly is partially explained by examining the sources of the O&M cost increase.

2. The Rise of Non–Force Structure O&M Costs

The 1994 study found that cost increases related to forces accounted for a little more than a quarter of the increase in O&M; the other increases were associated with a variety of other programs. Three-fourths of the 31.9 percent increase attributed to non-force structure–related cost was traced to environmental compliance, intelligence and communications programs, medical and health programs, administrative programs, and support to other nations. Table I-2 provides the details.

Table I-2. O&M Funding for Programs Insensitive to Force Size or Activity Levels (Millions of Constant FY 1995 Dollars)

FYDP Program	Category	FY1975	FY1995	Difference
Various	Environmental Compliance	0	3,578	3,578
3	Intelligence and Communications	5,378	10,180	4,802
8	Medical and Health	4,054	9,922	5,868
9	Administration and Associated Activities	3,423	5,229	1,805
10	Support to Other Nations	154	372	218
	Total	13,009	29,281	16,271

3. Where is the Force Structure–Related Cost Growth?

Other studies of FY 1975-95 programs and funding trends relate some O&M growth to an increase in the value of force structure equipment.[2] These papers pointed out that weapon system maintenance and support is logically related to asset value. For example, the cost of parts is directly related to weapon cost, and more maintenance man-hours are needed to maintain a more expensive and more complex weapon.

4. Which Weapons and Missions are Costing More?

This study tries to track down the weapons and mission areas responsible for the force structure–related O&S cost increases. In essence, it was to determine the

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2 Devers, Waynard C., and Alec W. Salerno, "An Analysis of Operating and Support Costs in the Department of Defense," Institute for Defense Analyses, Paper P-2706, September 1993; and Graves, Timothy J., and Joseph S. Domin, "Understanding the Increase in Department of Defense Funding," Institute for Defense Analyses, Paper P-3068, July 1995.

effectiveness of DoD's efforts to contain O&S costs. The framers of the study set down the following ideas to guide study development:

- For FYs 1975, 1985, 1995, use FYDP data that have been adjusted for changes in accounting practices;[3]
- Determine changes over time by O&S account, i.e., O&M and Military Pay Accounts;
- Separate changes into those that are sensitive to changes in force size and those that are independent of force size;
- Categorize results by Defense Mission Category (DMC), Major Force Program (MFP), and Readiness Categories established under an IDA-conducted, FYDP-based readiness study;
- Normalize findings for changes in the operating tempo (OPTEMPO) of the weapons or mission over time;
- Normalize findings for measures of capability or performance; and
- Investigate age and asset value as drivers of O&M costs.

B. RESEARCH APPROACH

Developing O&S trends for DoD equipment over the last 20 or 30 years is a sizable undertaking, one that could easily exceed the resources available for this study. To assess weapons systems O&S costs across the whole DoD, we needed a suitable way to chart overall changes at the service and Mission Category levels. Then, to explain these results, we needed to study some major modernization programs. We concluded that the following three-part effort would provide the most useful information, given the resource and data constraints:

- ***Department and Mission Category Analyses.*** Compare O&S costs for FYs 1975, 1985, and 1995 for the DoD as a whole, the services, and for selected major mission categories, and analyze the results with respect to changes in equipment levels, activity rates, capability, age, and asset value.
- ***Weapons System Case Studies.*** Compare O&S costs for the same years at the system-class level in selected Mission Categories as case studies.
- ***O&S Cost-Saving Modifications Studies.*** Investigate modification programs primarily undertaken to lower O&S costs to see if they have been successful.

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[3] A separate study was undertaken to deal with changes in FYDP accounting practices. See Appendix A.

C. DATA SOURCES

This study required a great deal of data pertaining to the operation and support of equipment used in the DoD over the last 20 or 30 years. All cost data presented in this report are expressed in constant FY 1996 dollars. Our data sources for each part of the study are noted below.

1. Department and Mission Category Analyses

O&S Cost Data. The primary source for broad service and Mission Category program data is the historical FYDP database. It is the most comprehensive source since data began to be collected from all DoD components in FY 1962. FYDP cost data, however, have two serious flaws:

- Funding policies have changed over time and the prior years in the FYDP database have not always been updated to reflect those changes. As a result, trend data can be biased by shifts in the accounting procedures for certain costs.
- The FYDP does not include depot maintenance costs other than depot-level reparables (DLRs) in the mission categories for the classes and models of Army equipment and for Navy equipment other than ships. The magnitude of mission category O&S costs in the Army and Navy is therefore understated. Furthermore, trends drawn from these data may be biased in cases where there are disproportionate shifts in depot maintenance costs.

The FYDP is, nevertheless, our best source of information. We compensate for the funding policy changes as much as possible, and note the FYDP's other limitations for the reader to take into account when reviewing our work. To minimize errors when making comparisons across time, we use a special FYDP database that includes adjustments for funding policy changes. Although that research is available separately as IDA Paper P-3194,[4] some materials from that paper are included as Appendix A to provide an overview of the policy change problem and its solution.

For service and military department analyses, we used the FYDP's O&M and Military Personnel appropriations data in FY 1996 constant dollars. For mission category analyses, we used these same data subdivided by Defense Mission Category. Appendix B

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4 IDA Paper P-3194, "Normalizing the Future Years Defense Program for Funding Policy Changes."

lists all DMCs for the department.[5] This study has focused on several primary force-oriented mission categories.

Equipment Levels. Navy and Air Force equipment data came from the FYDP.[6] The FYDP does not contain Army equipment data, so we used data the Army supplied from its Continued-Balance System Extended (CBSX) database. Ship Inventory data were taken from the Ships and Aircraft Supplemental Data Tables (SASDT).

Activity Rates. The Navy supplied ship steaming hours and aircraft flight hours; the Air Force supplied copies of their *Statistical Digest* containing these data; and the Army data were taken from Army management reports.

Capability. Capability data were derived from TASCFORM scores data. (See the next section for a description of TASCFORM.) Other measures were employed for "non-shooting" systems such as the "ton-miles-per-hour" ratio used for strategic mobility assets.

Age. Ship age data were taken from *Jane's Fighting Ships*. Navy aircraft age data were taken from the Navy's AG-3C report. The *Air Force Magazine* and *Air Force Statistical Digest* contained the data for Air Force Aircraft. The Army's *Gold Book* contained the data for Army aircraft.

Asset Value. Asset value data were calculated from the FYDP Procurement Annex or were found in Data Search Associates publications and RAND Corporation documents.

2. Capability Measurement

Inventory, activity, age, and cost data have conventional definitions and are easy to understand. Capability measures depend on many variables, and a single capability index is quite difficult to construct. We chose to use TASCFORM, a known capability index that is constructed in a systematic fashion for all DoD systems.

The following description of TASCFORM is taken from the study document done for the Office of the Assistant Secretary of Defense (Program Analysis and Evaluation), European and Pacific Forces Division.

> In 1978, the Analytic Sciences Corporation (TASC), began work for the Director of Net Assessment, Office of the Secretary of Defense, on a

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5 For a complete description of the DMCs and for program element assignments to each DMC, see IDA Paper P-3113, "A Reference Manual for Defense Mission Categories, Infrastructure Categories, and Program Elements."

6 Primary Aircraft Authorization (PAA) is used for aircraft inventory data.

project intended to develop a method to quantitatively measure military force modernization. That initial project has evolved into a comprehensive method for determining general purpose force potential based on the measured performance characteristics of specific military systems. This method is known as TASCFORM™—Technique for Assessing Comparative Force Modernization. TASCFORM™ includes a series of weapon system assessment models and a series of companion models to measure the qualitative non-weapon aspects of military forces (personnel, command and control, logistics)...TASCFORM™ provides static indicators of military force potential called measures of effectiveness (MOEs). The measurements of effectiveness are based on characteristics and quantities of individual weapon systems and are expressed as numerical scores. Individual system measures of effectiveness for aircraft, missiles, rockets, guns, combat vehicles, and other weapon systems are determined by comparing performance characteristics such as payload, range, speed, maneuverability, strategic mobility and targeting and guidance subsystems to those same characteristics of a selected baseline weapons system. The relative importance of these characteristics for each weapon system is accounted for through the use of weighting factors developed by panels of experts using Delphi techniques. TASC, and its sponsors have held numerous symposia at which operationally experienced representatives of all branches of the Armed Forces and the defense intelligence/analysis community indicated their preferences for the weighting coefficients used to assign relative importance to various weapons system characteristics.... All analytical models have limitations. TASCFORM is a static assessment model and has many of the limitations of static models. TASCFORM is not a predictor of combat outcomes. It is an indicator of force potential. It does not interact dynamically and cannot measure the synergy between and among systems in combat.[7]

Early in our study, the sponsors agreed that TASCFORM would be used, where appropriate, as the MOE for our analysis. Although there is widespread and valid concern over the use of TASCFORM as the primary MOE used in this study, the sponsors acknowledged that TASCFORM provides a recognized way to compare systems of like design. We used TASCFORM to compare aircraft to aircraft or ships to ships only. We did not try to compare the capability of a tank to the capability of a fighter aircraft. Utilization of TASCFORM is, we believe, a reasonable approach in this study. No inferences should be taken from the absolute number obtained through the use of

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7 *The TASCFORM™ Methodology: A Technique for Assessing Comparative Force Modernization (Sixth Edition)*, 12 February 1993, Report TR-6863-1. TASCFORM™ is a trademark of The Analytic Sciences Corporation.

TASCFORM; the purpose is to show relative change in the capability of new versus old system designs.

3. Weapons System Case Studies

O&S Cost Data. Almost all O&S cost data used in the case studies were drawn from each service's VAMOSC data collection system.[8] Exceptions are noted in each case study.

D. STUDY METHODOLOGIES

1. Department Analysis Methodology

The primary goal of the study was to identify specific missions and weapons that contributed substantially to DoD's O&S growth during the FY 1975-95 period. We began this investigation by looking first at the shares of growth among the departments and agencies. Figure I-1 shows the growth and decline of O&S expenditures among the DoD components during the FY 1975-95 time period. The data used for Figure I-1 have been normalized to FY 1975 so that we can see the relative change between FY 1975 and FY 1985 and then again from FY 1985 to FY 1995.

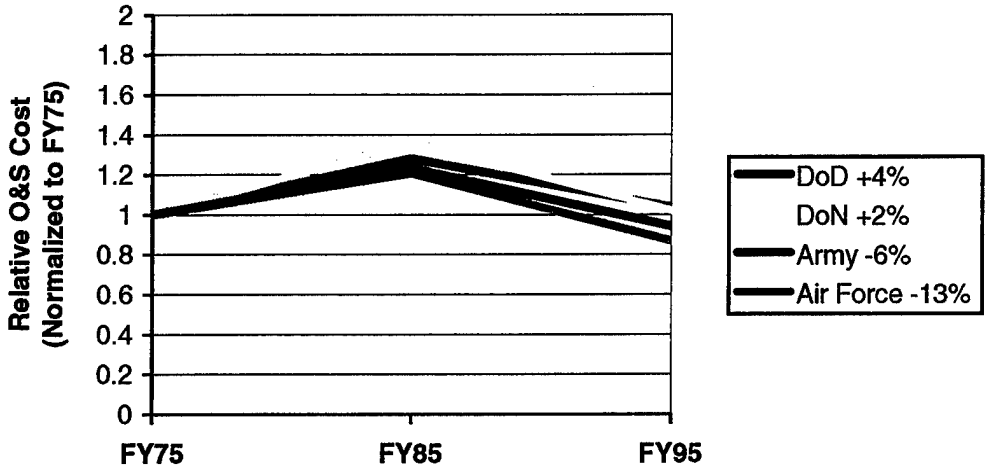

Figure I-1. DoD and Service O&S Trends

8 The Visibility and Management of Operating and Support Costs (VAMOSC) program collects and validates operating and support cost data for the major weapons systems in the Department of Defense.

For the FY 1975-95 period, DoD grew 4 percent, Navy grew 2 percent, Army declined 6 percent, and Air Force declined 13 percent. These figures are a combination of substantial reductions in military personnel costs and substantial increases in O&M costs. O&S costs for agencies grew 169 percent from FY 1975 to FY 1995. Although a separate line for agencies is not shown, 169 percent would plot at 2.69 if values on the y-axis went that high. Much of that increase is non–force-related program growth. Agency O&S does not include military pay, since agency military personnel cost is borne entirely by the military departments. Figure I-2 shows O&M only.

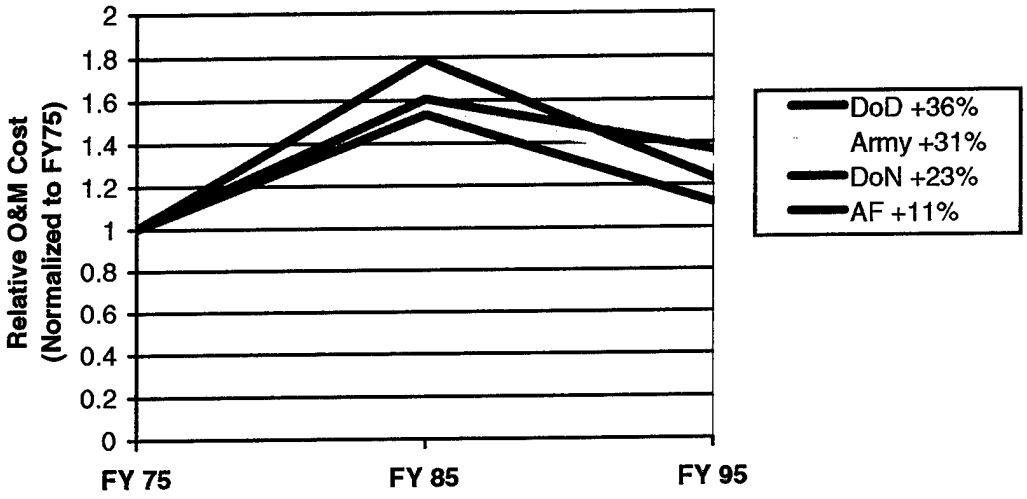

Figure I-2. DoD and Service O&M Trends

For the FY 1975-95 period, DoD O&M costs grew by 36 percent; Army, by 31 percent; Navy, by 23 percent; and Air Force, by 11 percent. These growth statistics are startling considering the reductions in force structure shown in Table I-1.

This general methodology of stratifying data and calculating growth rates for successively smaller portions of the DoD and each military department is continued in Sections III, IV, and V. We have not established a standard or common methodology for assessing each military department's overall force-related O&S experience. The departments have very different organizations and missions, and the available data differed, as did the questions posed by the members of the study's Steering Group and by the Technical Point-of-Contact. These questions led the analysis deeper into some areas than others. There is, for example, a series of charts that respond to questions about the Navy's goal of acquiring and maintaining a fleet of 600 warships.

2. Mission Category Analysis Methodology

Basic Data Collection and Calculations. The data for each mission category have been placed in tables similar to Table I-3. In each mission category, the data from this table produce three different visual displays. Our Type 1 comparison chart uses the data in the first eight items in Table I-3 to show the percentage change in mission category program data. Three time periods are shown: FY 1975 to FY 1985, FY 1985 to FY 1995, and FY 1975 to FY 1995. An example of a ***Type 1 comparison*** is shown in Figure I-3.

Table I-3. Example Mission Category Data Table: USAF Active Air-to-Ground Mission (Cost Data in Constant FY 1996 Dollars)

Data Descriptions	Example	FY75	FY85	FY95
Operating Equipment Count	Aircraft	1572	1266	714
Total O&S Costs ($M)	O&S	3,238	3,650	2,256
Total O&M Costs ($M)	O&M	1,558	2,234	1,343
Total Military Personnel Costs ($M)	MilPers	1,679	1,416	913
Total Activity Measurement	Flying Hours	503,475	173,600	260,232
Total Equipment Asset Value ($M)	Asset Value	25,134	28,184	23,842
Total Capability Measurement	Capability Index	23,257	14,199	15,361
Equipment Average Age (years)	Average Age	6.5	8.1	9.4
O&S Cost per Equipment Count	Per Aircraft ($K)	2,060	2,883	3,160
O&S Cost per Activity Measure	Per Flight Hour ($)	6,431	21,023	8,671
O&S Cost per unit of Asset Value	Per 100K Asset Value	12,881	12,949	9,464
O&S Cost per unit of Capability	Per Capability Unit ($H)	1,392	2,577	1,467
Equipment Count for Major Weapons	A-7	216	0	0
	A-10	0	300	72
	F-4	1,044	312	24
	F-15E	0	0	138
	F-117A	0	0	36
	F-105	36	0	0
	F-111	276	198	54
	F-16	0	456	390

[a] Detail does not add to total due to rounding.
[b] We have used the symbol ($H) to mean hundreds of dollars throughout this report.

Our Type 2 comparison chart uses the next four items in Table I-3 to show changes in O&S cost per equipment count, per activity measure, per unit of asset value, and per unit of capability. Figure I-4 is a ***Type 2 Comparison.***

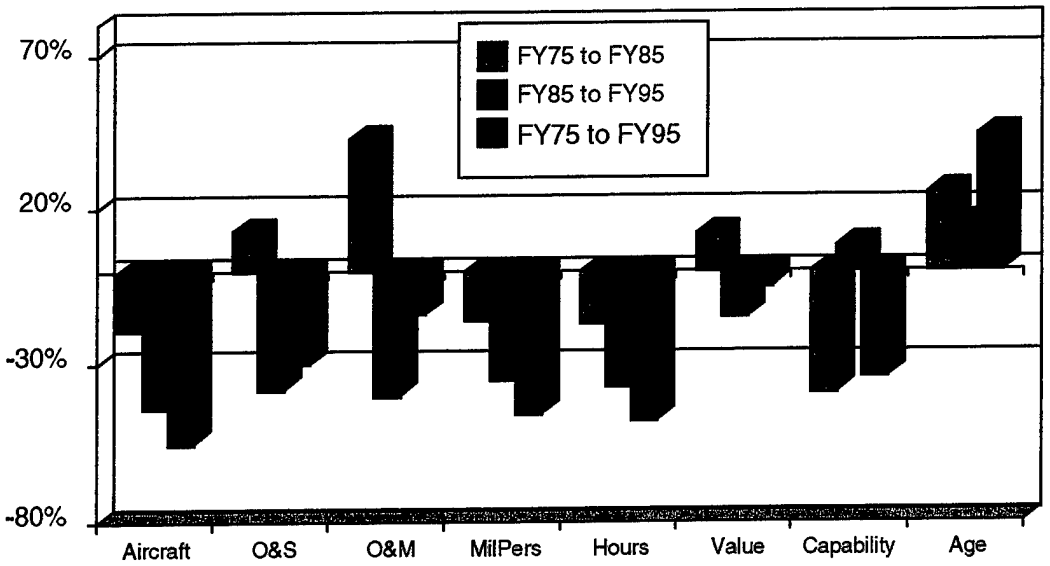

Figure I-3. Type 1 Example: Active Air Force Air-to-Ground Mission Category Cost and Program Data Totals Comparison

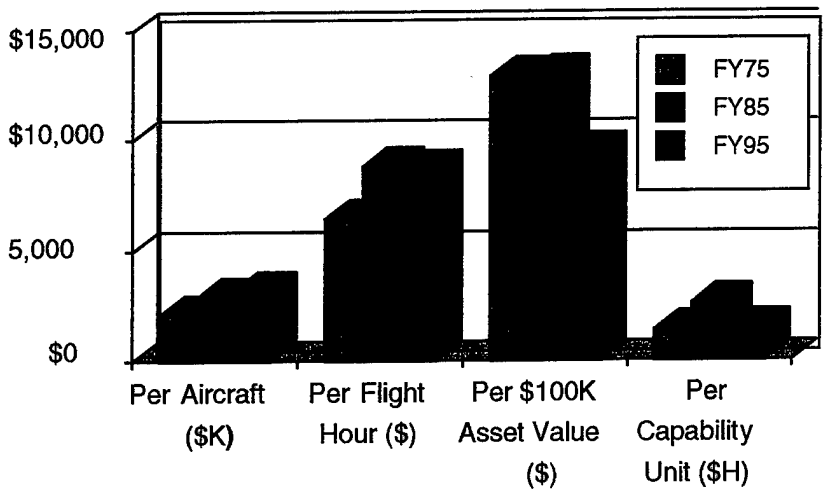

Figure I-4. Type 2 Example: Active Air Force Air-to-Ground Mission Category O&S Costs By Program Attribute (In Constant FY 1996 Dollars)

The Type 3 comparison, Figure 1-5, uses the same data as the Type 2 comparison, but portrays them as a percentage change from FY 1975.

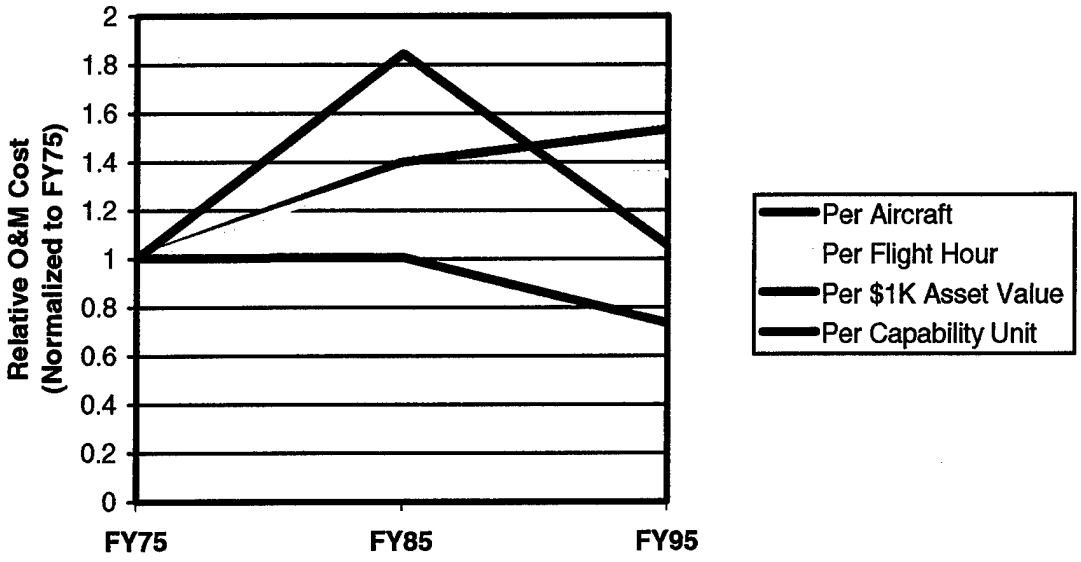

Figure I-5. Type 3 Example: Active Air Force Air-to-Ground Mission Category Percent Change in O&S Costs by Program Attribute

The study has relied mainly on display types 1 and 3, which focus on percentage changes. Display type 2 is included for information purposes only. It presents a visual image of changes that is affected by absolute values. In Figure I-4, for example, the decrease in O&S cost per $100K asset value from FY 1985 to FY 1995 is larger in dollar terms than the change in dollars per unit of capability. However, expressed as percentages, the decrease in cost per $100K asset value between FY 1985 and FY 1995 is actually less than the decrease in the cost per unit of capability. While the absolute values are often helpful, they can mislead the unwary reader.

3. Weapons System Case Studies Methodology

Basic Data Collection and Calculations. We have placed the data for each weapons system case study in tables similar to Tables I-4 and I-5. Table I-4 displays weapons system characteristics and Table I-5 displays the O&S costs for the elements of cost pertaining to the system under study. We have shown all data on a "per-unit" basis.

Table I-4. Example Weapon System Case Study Characteristics Data Table: Army M60A3 and M1A1 Tanks

	M60A3	M1A1
Combat Weight (tons)	57.3	67
Dimensions (feet)		
Length	31	32.25
Height	12	12
Top Speed (mph)	30	41.5
Powerplant	12-cylinder diesel	1,500-horsepower turbine
Fuel Capacity (gallons)	375	504
Crusing Range (miles)	280	310
Crew	4	4
Armament		
Main Gun	105 mm	120 mm
Machine Guns	—	1 .50 caliber
	1 7.62 mm	2 7.62 mm
	1 12.7 mm	1 12.7 mm
Asset Value ($Ks)	$1,291	$2,003
TASCFORM Score	3.702	6.269

Table I-5. Example Weapon System Case Study O&S Cost Table: Army M60A3 and M1A1 Tanks (Constant FY 1996 Dollars)

	M60A3	M1A1
Fuel	792	2,405
Ammunition	13,582	37,657
Consumables	4,198	21,649
Repairables (Net)	15,762	49,348
Intermediate Maintenance	915	389
Depot Maintenance (End Item)	500	7,899
Total Direct O&S Cost	35,749	119,347
Typical Miles Per Year (Active Duty Status)	500	500
O&S Cost Per Mile	71	239
Cost Ratio	1.00	3.34

Notes: O&S costs are from the Army's OSMIS data system. M60A3 data are from the FY 1986 to FY 1991 period. M1A1 costs are based on FY 1990 to FY 1994 operating data.

II. DEPARTMENT OF THE ARMY

A. DEPARTMENTAL OVERVIEW

The Army experienced a 6-percent decrease in O&S costs between FY 1975 and FY 1995; at the same time, O&M costs rose by 24 percent. The Army reduced military personnel costs substantially during this period, which more than offset the O&M increase. To get a broader view of these changes, we will first look at Army active, guard, and reserve combat forces. In these broad component categories, O&M cost changes sometimes did not parallel changes in force levels. Figure II-1 illustrates the relationships found between end-strength and O&M changes.

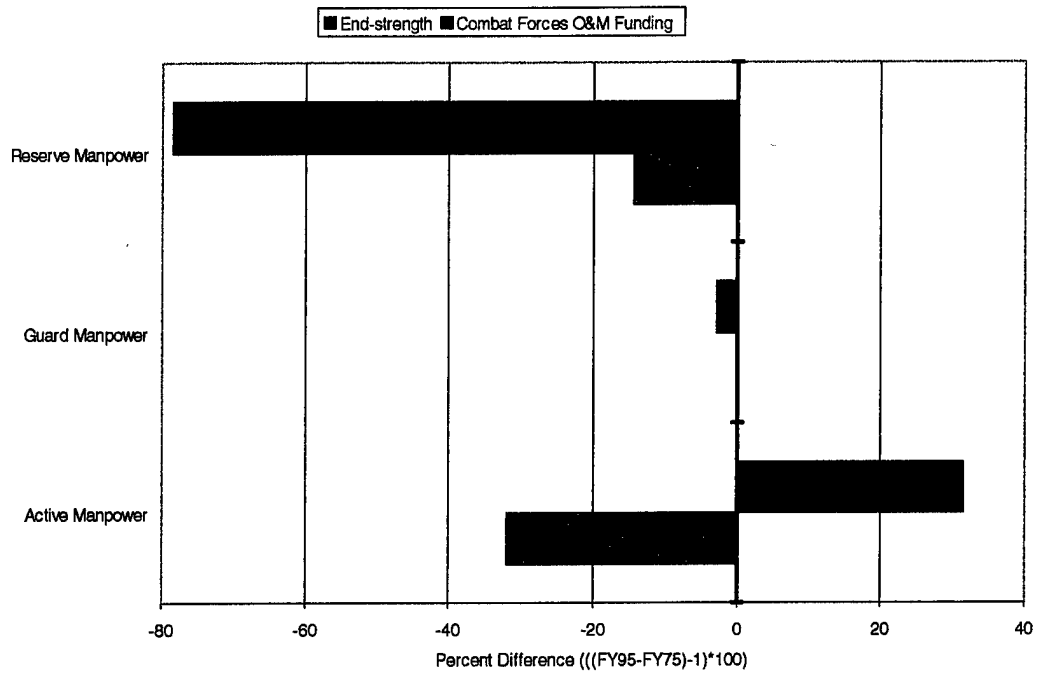

Figure II-1. Percent Change in End-Strength Compared with Percent Change in O&M

Figure II-2 shows five categories of Army equipment used in the active forces we tracked over this same period. The number of ground weapons systems and attack helicopters grew substantially during the FY 1975-95 period, as did the total amount of

O&M used by those systems. More important, the O&M needed to support each weapon increased as well. The number of observation and utility helicopters dropped by 35 and 25 percent respectively. While the total O&M for the observation helicopters dropped 31 percent, O&M increased substantially for utility helicopters. In summary:

- **Tanks** increased almost 100 percent and total O&M increased over 300 percent. O&M cost per tank increased 103 percent.[1]
- **Infantry Fighting Vehicles (IFV)** increased 72 percent and total O&M increased 819 percent;[2]
- **Attack Helicopters** increased 82 percent and total O&M increased 157 percent.[3]
- **Observation Helicopters** decreased 35 percent and total O&M decreased by 31 percent.
- **Utility Helicopters** decreased 25 percent and O&M increased 56 percent.

Table II-1 provides more details about these findings.

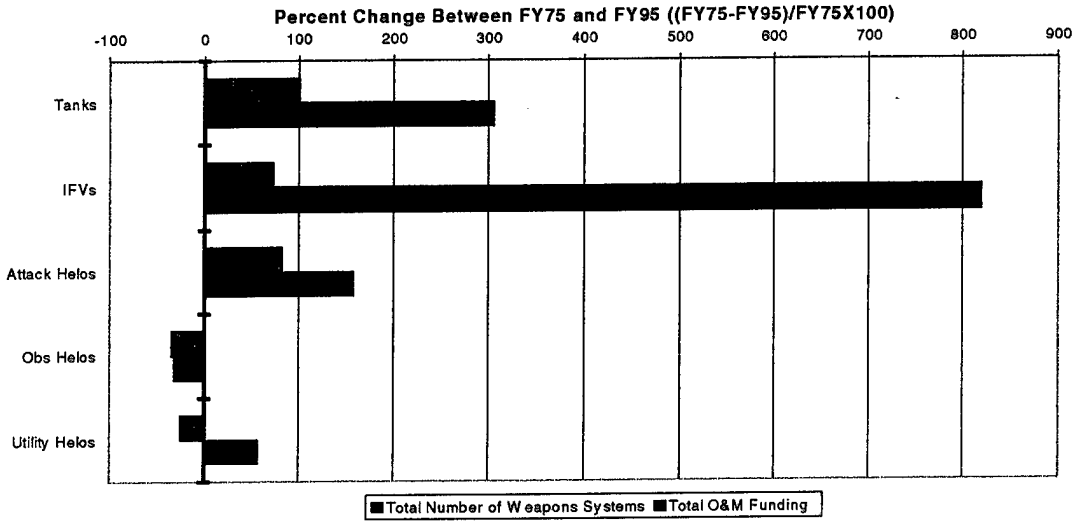

Figure II-2. Weapon Inventory and O&S Costs for Selected Army Equipment Categories

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1 FY 1975 miles per tank data unavailable. 820 miles per tank per year used for both FY 1975 and FY 1995.

2 FY 1975 miles per vehicle data unavailable. 1,418 miles per vehicle per year used for both FY 1975 and FY 1995 for the M3 series; approximately half that number was used for M113 and M2 series vehicles.

3 FY 1975 hours per aircraft data unavailable. O&M and flying hours required to fly C-1 rating OPTEMPO in 1994 were used for both FY 1975 and FY 1995 for all helicopters.

Table II-1. Percent Change in Selected Army Equipment Between FY 1975 and FY 1995

Data Element	Tanks	IFVs	Attack Helos	Observation Helos	Utility Helos
Total Number of Weapons Systems	100	72	82	-35	-25
Total O&M Funding	305	819	157	-31	56
Total Military Personnel Pay	—[a]	—[a]	—[a]	—[a]	—[a]
Total O&S	305	819	157	-31	56
Total Miles or Flying Hours	100	110	78	-35	-25
Total Asset Value	228	412	285	-27	166
Total Capability Units	242	161	339	—[b]	23
Average Age	10	62	155	383	182
Miles or Fly Hours Per Weapon System	0	22	-2	0	0
O&M Per Weapon System	103	433	41	6	107
O&M Per Flying Hour	103	337	45	6	108
O&M Per $10K Asset Value	24	79	-33	-5	-41
O&M Per Capability Unit	19	252	-41	—[b]	27

[a] Military personnel cost not available.

[b] Capability units undefined.

B. MISSION CATEGORY REVIEW

1. Analyses by Defense Mission Category (DMC)

For the Army's mission category review, we chose to study tanks, infantry fighting vehicles, attack helicopters, observation helicopters, and utility helicopters. These weapons systems are generally found in a series of Defense Mission Categories that house the Army's combat forces. These include Divisions, Non-Division Combat Forces, and Special Mission Forces. Although most of the equipment for Army forces is included in the above categories of FYDP program elements, costs for individual systems or specific equipment types cannot be separately identified in FYDP data. We used Army VAMOSC, inventory, and age data to supplement the data found in the FYDP.

2. Tanks

Table II-2, which contains all of the basic data we collected for this mission area, shows that the number of tanks nearly doubles over the FY 1975-95 period, and the total O&M for tanks quadruples. As a result, average O&M per tank increases by slightly over 100 percent and average O&M per tank-mile increases by a little over 100 percent as well.

Actual miles per tank were unavailable for FY 1975 so we held the figure steady at 820 miles per tank per year.

Table II-2. Tank Data
(Cost Data in Constant FY 1996 Dollars)

Data Element		FY75	FY85	FY95
Tanks		4,405	11,303	8,810
O&M ($M)		198	646	804
Miles (K)		3,612	9,268	7,224
Asset Value ($M)		4,775	13,864	15,644
TASCFORM		14,989	45,159	51,203
Average Age		8.6	10.0	9.5
O&M Per Tank		45,002	57,141	91,214
O&M per Mile		55	70	111
O&M per $10K Asset Value		415	466	514
O&M per Capability Unit		13,225	14,302	15,694
Equipment Data	M60A1	2,182	3,734	3
	M60A2/3	2,223	5,222	1,344
	M1	0	2,343	2,923
	M1A1	0	4	4,540

Turning next to Figure II-3, we find that changes in total O&M, number of tanks, and total miles are as expected. The increase in total asset value is consistent with the increase in the size of the force and the shift to the more expensive M1s. The increase in capability is also consistent with the large increase in force size and the higher ratio of M1s to M60s.

Figure II-4 shows the FY 1975, FY 1985, and FY 1995 values for the O&M cost ratios shown in Table II-2. O&M cost per tank, per mile, per unit of asset value, and per unit of capability have all increased.

How has modernization affected the weapons inventory of this mission area? As shown in Table II-2, we find that tank modernization has been substantial during this period.

- M60s decrease from 4405 to 1347, and
- M1s increase from 0 to 7463.

How has modernization changed mission operating costs? Looking at the annual operating cost figures for individual tanks in Table II-3, we find that the M1 tank requires more than twice the O&M budgeted each year for the M60.

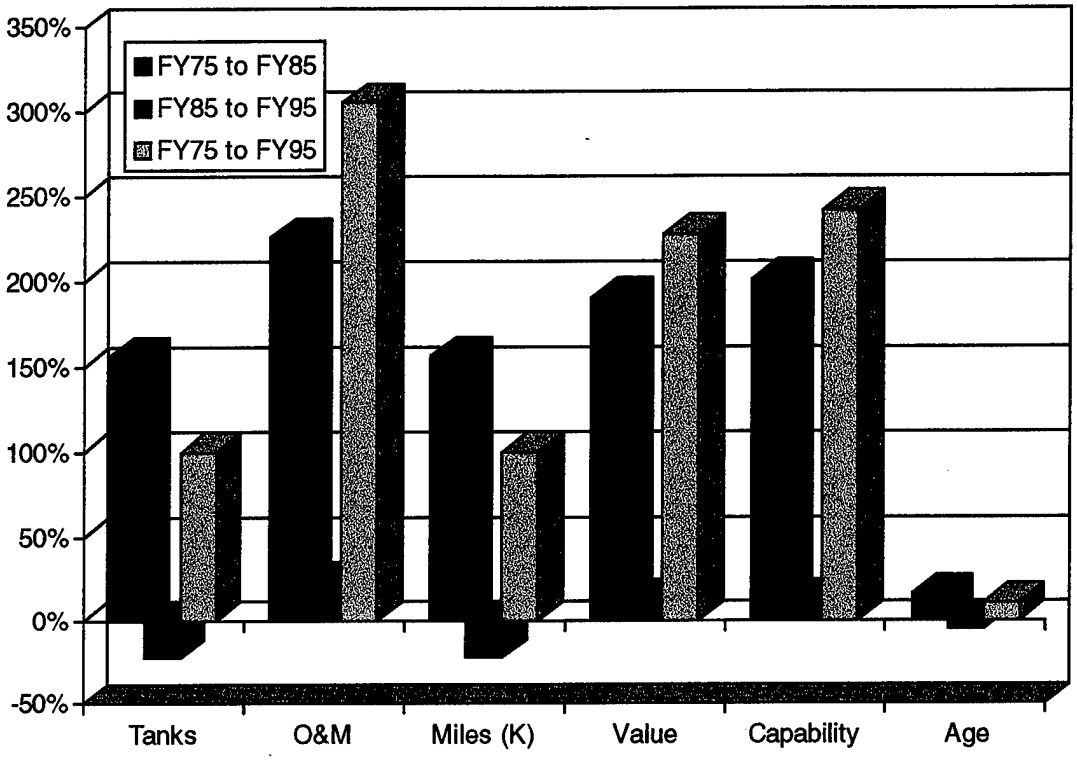

Figure II-3. Tanks: Total Resources and Performance Changes

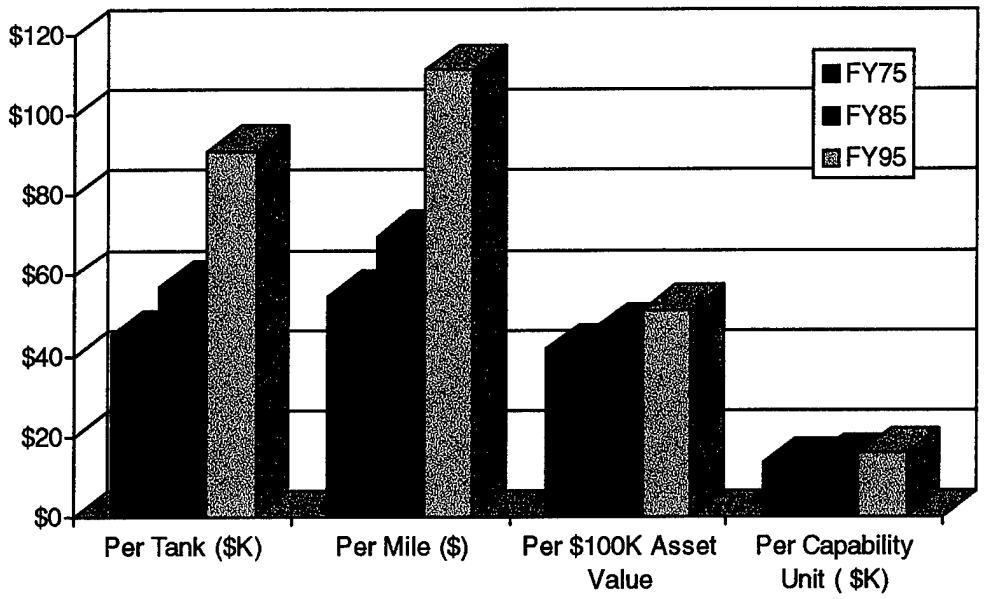

Figure II-4. Tank O&M Cost Ratio Changes

Table II-3. Tanks Annual O&M (Constant FY 1996 $)

Type & Class	O&M
M1	103,476
M60	45,002

3. Infantry Fighting Vehicles

Table II-4 shows that between FY 1975 and FY 1995 the number of infantry fighting vehicles increased by 72 percent, their total annual mileage increased by 111 percent, and their total O&M cost increased by 826 percent. As a result, average O&M per vehicle increased by 433 percent and average O&M cost per mile increased by 360 percent. Figure II-5 shows these data in chart form. Total asset value increased 412 percent and capability increased by almost 161 percent.

Table II-4. Infantry Fighting Vehicle Data (Cost Data in Constant FY 1996 Dollars)

Data Element		FY75	FY85	FY95
Vehicles		8,670	13,979	14,943
O&M ($M)		31	140	287
Miles (K)		6,060	10,597	12,757
Asset Value ($M)		1,769	4,631	9,055
TASCFORM		15,008	28,326	39,229
Average Age		8.4	13.1	13.6
O&M Per Vehicle		3,607	10,023	19,233
O&M per Mile		5	13	23
O&M per $10K Asset Value		177	303	317
O&M per Capability Unit		2,084	4,946	7,326
Equipment Data	M113A1/2/3	8,670	11,859	8,088
	M2A1/2	0	1,264	4,733
	M3A1/A2	0	856	2,122

Figure II-6 shows that all ratios increased. From FY 1975 to FY 1995 O&M cost per vehicle increased by 433 percent and O&M per mile increased by 360 percent. O&M cost per unit of asset value increased by 79 percent and O&M cost per unit of capability grew by 252 percent.

The Army has substantially modernized the Infantry Fighting Vehicle inventory during the FY 1975-95 period. Table II-5 focuses on infantry fighting vehicle inventories from Table II-4. The M113 family of vehicles dropped by 582 during the FY 1975-95 period. A total of 6,855 vehicles in the M2 and M3 vehicle families were introduced during the period.

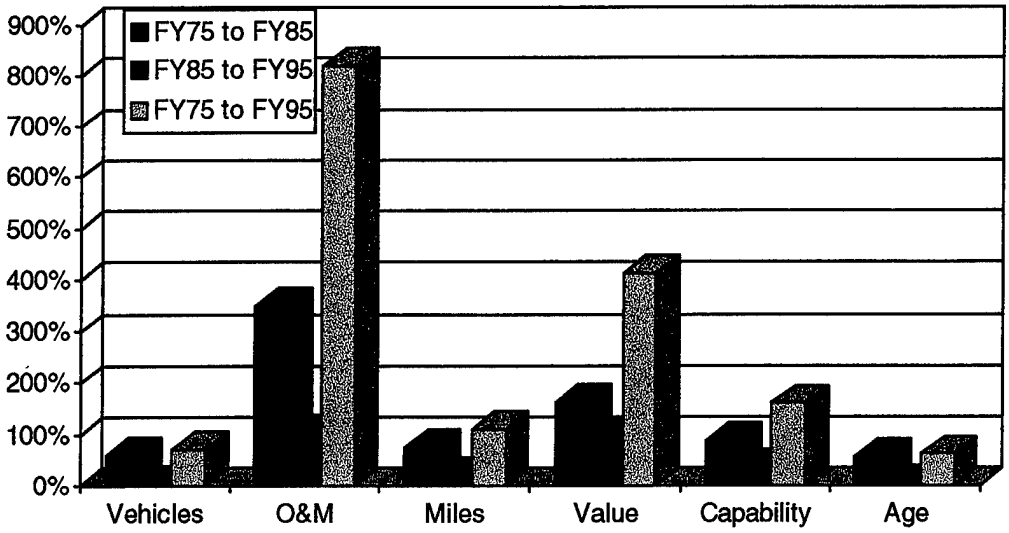

Figure II-5. Infantry Fighting Vehicle Mission Total Resources and Performance Changes

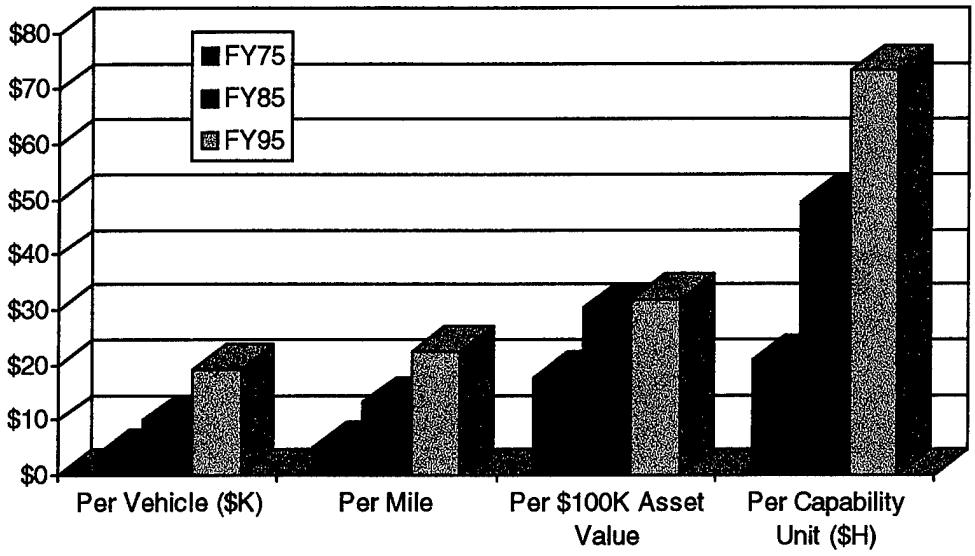

Figure II-6. Infantry Fighting Vehicle O&S Cost Ratio Changes

Table II-5. Infantry Fighting Vehicle Modernization

Vehicle Type	FY75	FY95
M113A1/2/3	8,670	8,088
M2A1/2	0	4,733
M3A1/A2	0	2,122

Modernization has increased operating costs. The annual operating cost figures for individual vehicles shown in Table II-6 indicate that the M113s were much less expensive to operate than the M2s or M3s.[4]

Table II-6. Infantry Fighting Vehicle Annual O&M Operating Costs (FY 1996 $)

Vehicle Type	O&M
M113A1	7,185
M113A2	7,185
M113A3	7185
M2	50,689
M2A1	17,280
M2A2	44,580
M3	82,818
M3A1	82,818
M3A2	63,318

4. Attack Helicopters

Table II-7 data shows that between FY 1975 and FY 1995:

- The total number of aircraft increased 82 percent while flying hours increased by 78 percent.
- There is a 157 percent increase in total O&M.
- Asset Value increased by 285 percent and mission capability increased by 339 percent.

Figure II-7 shows these data in chart form.

Looking next at the "per unit" section of the Table II-7, notice that between FY 1975 and FY 1995 O&M cost:

- Per aircraft increased by 41 percent,
- Per flying hour increased by 44 percent,
- Per $100K of Asset Value dropped by 33 percent, and
- Per unit of capability dropped by 41 percent.

Again, Figure II-8 shows these data in chart form.

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4 Notes on the figures in Table II-6: the M2A2 and M3A2 models are less expensive to operate than earlier models in each series because they have an improved engine and drive train. The M2A1 is markedly less expensive than other M2 models because it currently has a much lower annual activity rate.

Table II-7. Attack Helicopter Data
(Cost Data in Constant FY 1996 Dollars)

Data Element		FY75	FY85	FY95
Aircraft		766	1,140	1,393
O&M ($M)		205	326	527
Hours		133,046	201,898	236,370
Asset Value ($M)		2,920	4,599	11,248
TASCFORM		1,538	2,655	6,754
Average Age		5.3	11.5	13.5
Flying Hours Per Aircraft		174	177	170
O&M Per Aircraft ($K)		268	286	378
O&M Per Flight Hour ($)		1,544	1,613	2,228
O&M Per $10K Asset Value ($)		703	708	468
O&M Per Capability Unit ($K)		134	123	78
Equipment Data	AH-1E		97	23
	AH-1F	352	501	490
	AH-1G	31	11	3
	AH-1P	2	95	10
	AH-1S	381	389	121
	AH-64A		47	746

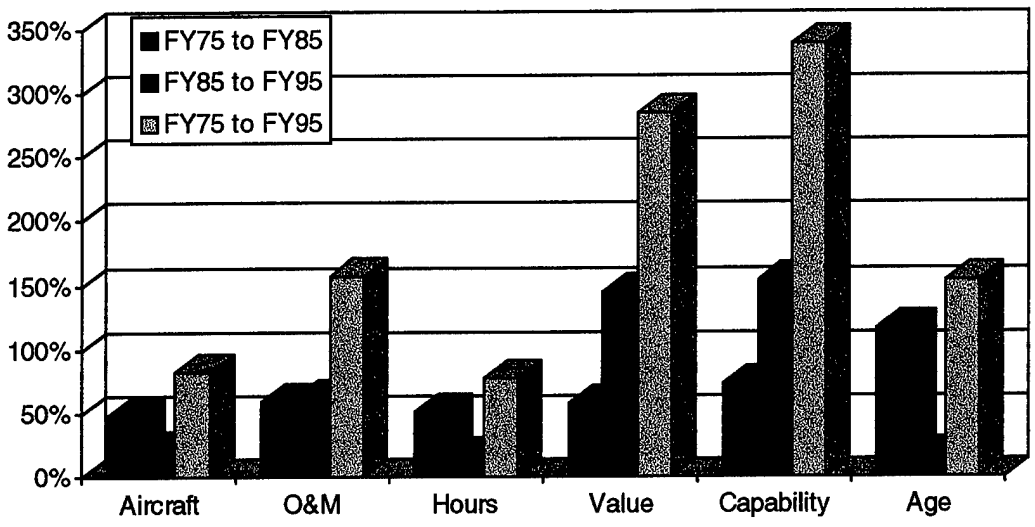

Figure II-7. Attack Helicopters
Total Resource and Performance Changes

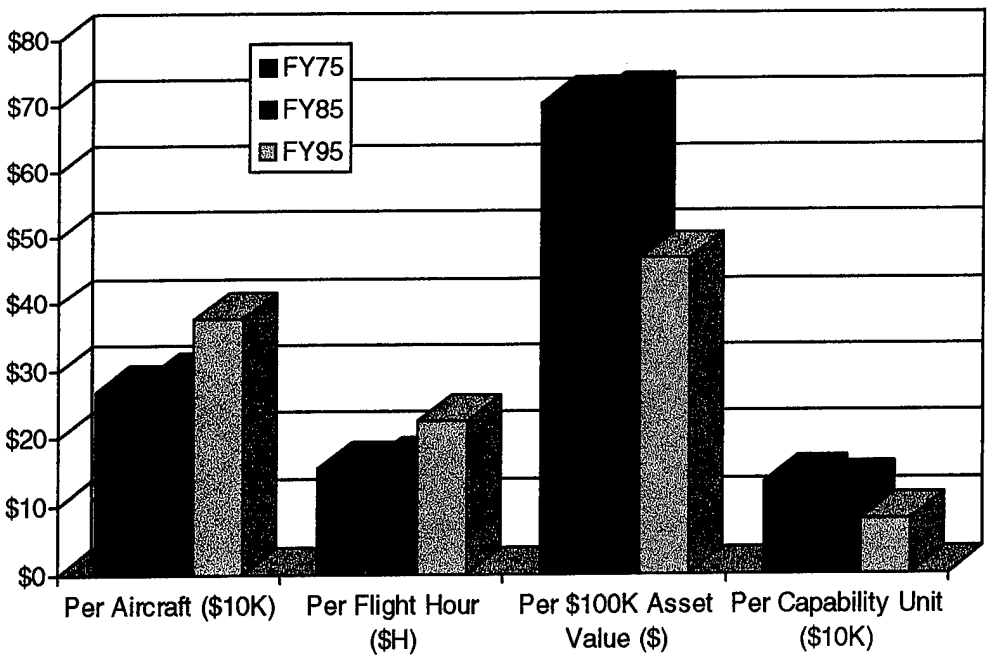

Figure II-8. Attack Helicopter O&S Cost Ratio Changes

Table II-8. Attack Helicopter Modernization

Aircraft Type	FY75	FY95	Change
AH-1S	381	121	-260
AH-1G	31	3	-28
AH-1E	-	23	23
AH-1P	2	10	8
AH-1F	352	490	138
AH-64A		746	746

There was a marked modernization of attack helicopters during this period. Table II-8 focuses on attack helicopter inventories from Table II-7. The Army phased out over 300 older AH-1s during the period and introduced over 700 new AH-64s.

Modernization has had a substantial effect on operating costs. The annual operating cost figures for attack helicopters shown in Table II-9 indicate that the AH-64s are nearly twice as expensive as the AH-1s.

Table II-9. Attack Helicopter Annual O&M Costs (FY 1996 $M)

Aircraft Type	O&M ($M)
AH-1S	0.31
AH-64	0.57

In summary, the Army's experience in this mission area is typical of one in which substantial modernization has taken place during the 20-year period:

- O&M cost per flight hour is up,
- O&M cost per unit of asset value is down,
- O&M cost per unit of capability is down, and
- O&M cost per aircraft has been managed down somewhat by reducing flying hours.

The flying hour reduction per aircraft is small:

- In FY 1975, 133,046 flying hours were allocated among 766 aircraft to produce an average of 174 flying hours per aircraft per year.
- In FY 1995, 236,370 flying hours were allocated among 1,393 aircraft to produce an average of 170 flying hours per aircraft, a decrease of approximately 2 percent.

Altogether, changes in the number and mix of aircraft between FY 1975 and FY 1995 and the differences in their operating costs substantially account for the $322 million increase in O&M costs in Table II-7.

5. Observation Helicopters

Table II-10 shows that between FY 1975 and FY 1995:

- The total number of aircraft decreased 35 percent.
- There is a 30-percent decrease in total O&M.
- Asset Value decreased by 27 percent.

Because these changes are so similar, these data produce an unusual picture in Figure II-9.

Table II-10. Observation Helicopter Data (Cost Data in Constant FY 1996 Dollars)

Data Element		FY75	FY85	FY95
Aircraft		2,470	2,324	1,606
O&M ($M)		120	113	83
Hours		481,650	453,180	313,170
Asset Value ($M)		313	297	228
TASCFORM			Not Available	
Average Age		4.0	14.0	19.3
Flying Hours Per Aircraft		195	195	195
O&M Per Aircraft ($K)		49	49	51
O&M Per Flight Hour ($)		250	250	264
O&M Per $10K Asset Value ($)		3,842	3,816	3,629
Equipment Data	OH-58A	1,479	1,368	782
	OH-58C	594	582	443
	OH-58D	5	7	327
	OH-6A	392	367	54

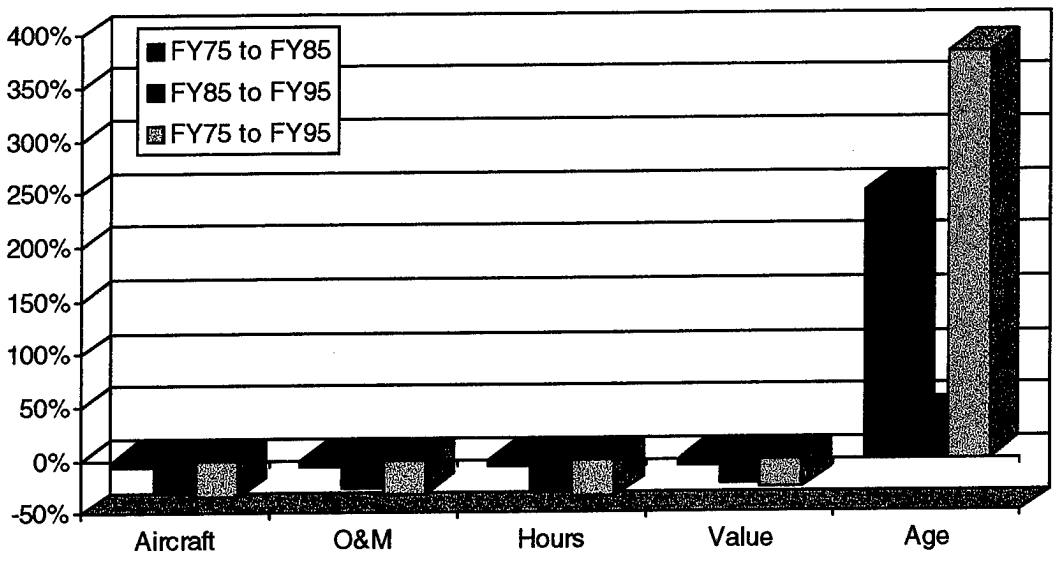

Figure II-9. Observation Helicopters Total Resource and Performance Changes

The "per unit" section of the Table II-10 shows that between FY 1975 and FY 1995, the O&M cost:

- Per aircraft increased by 4 percent,
- Per flying hour increased by 6 percent, and
- Per $100K of Asset Value dropped by 6 percent.

Figure II-10 shows these data in chart form.

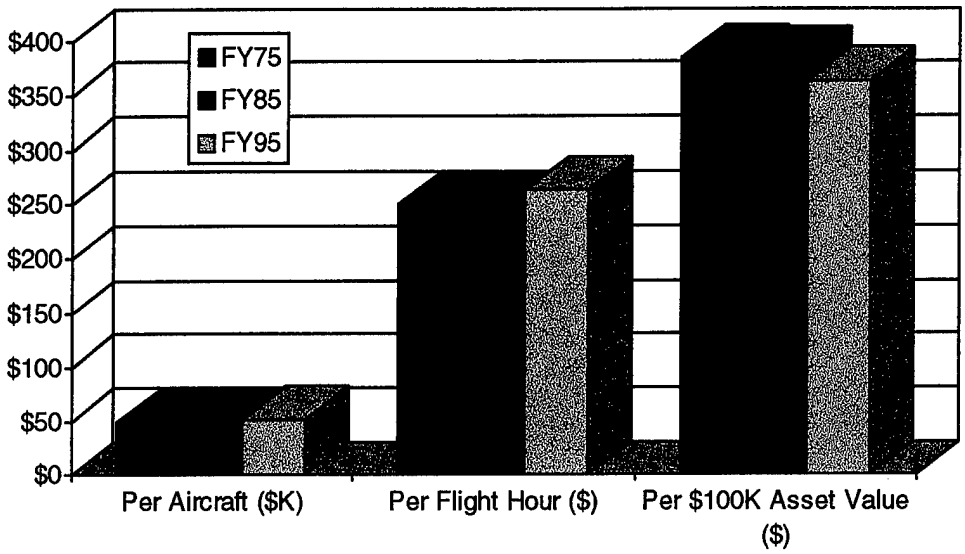

Figure II-10. Observation Helicopter O&S Cost Ratio Changes

The Army bought new models of observation helicopters and reduced the size of its fleet during this period. Table II-11 focuses on observation helicopter inventories from Table II-10. The Army phased out 338 older OH-6A and 848 OH-58A-C models during the period and introduced 322 new OH-58Ds.

Table II-11. Observation Helicopter Modernization

Aircraft Type	FY75	FY95	Change
OH-6A	392	54	-338
OH-58A	1,479	782	-697
OH-58C	594	443	-151
OH-58D	5	327	+322

Modernization has increased operating costs for observation helicopters. The annual operating cost figures shown in Table II-12 indicate that the OH-6s were much cheaper to operate than the OH-58s.

Table II-12. Observation Helicopter Annual O&M Costs (FY 1996 $K)

Aircraft Type	O&M ($K)
OH-6	34.0
OH-58	67.0

In summary, the Army's experience in this mission area is one in which some modernization has taken place during the 20-year period. Also, a significant drawdown in the number of aircraft changed the model mix enough so that:

- O&M cost per flight hour is up, and
- O&M cost per unit of asset value is down.

The change in the number and mix of aircraft between FY 1975 and FY 1995 substantially accounts for the $37 million decrease in O&M costs shown for observation helicopters in Table II-10.

6. Utility Helicopters

The main findings in this section are that O&M cost per flight hour is up over the 20-year time period covered and O&M cost per unit of asset value is also up. The increase in O&S cost per unit of asset value is different from most other mission areas where there is a significant amount of modernization.

Table II-13 contains all of the basic data we collected for this mission area.

An examination of Table II-13 reveals several important changes. First notice that between FY 1975 and FY 1995:

- The total number of aircraft decreased 25 percent;
- There is a 56-percent increase in total O&M; and
- Asset value increased by 166 percent, and mission capability increased by 23 percent.

Let's refer now to our standard graphic presentation of these data in Figure II-11. Notice the substantial increase in average age.

Now look at the "per unit" section of Table II-13. Notice that between FY 1975 and FY 1995 the O&M cost:

- Per aircraft increased by 107 percent,
- Per flying hour increased by 207 percent,
- Per $100K of Asset Value dropped by 166 percent, and
- Per unit of capability increased by 27 percent.

Again, Figure II-12 shows these data in chart form.

Table II-13. Utility Helicopter Data
(Cost Data in Constant FY 1996 Dollars)

Data Element		FY75	FY85	FY95
Aircraft		4,430	4,427	3,335
O&M ($M)		331	476	517
Hours		952,450	951,131	715,783
Asset Value ($M)		3,598	7,716	9,558
Ton-miles per hour		945,362	1,191,810	1,167,006
Average Age		6.6	13.8	18.6
Flying Hours Per Aircraft		215	215	215
O&S Per Aircraft ($K)		75	108	155
O&S Per Flight Hour ($)		348	500	722
O&S Per $10K Asset Value ($)		920	617	540
O&S Per Capability Unit ($)		350	399	443
Equipment Data	UH-1B	430	55	38
	UH-1H	3,322	3,066	1,688
	UH-1M	309	246	
	UH-1V	369	386	367
	UH-60A		674	926
	UH-60L			316

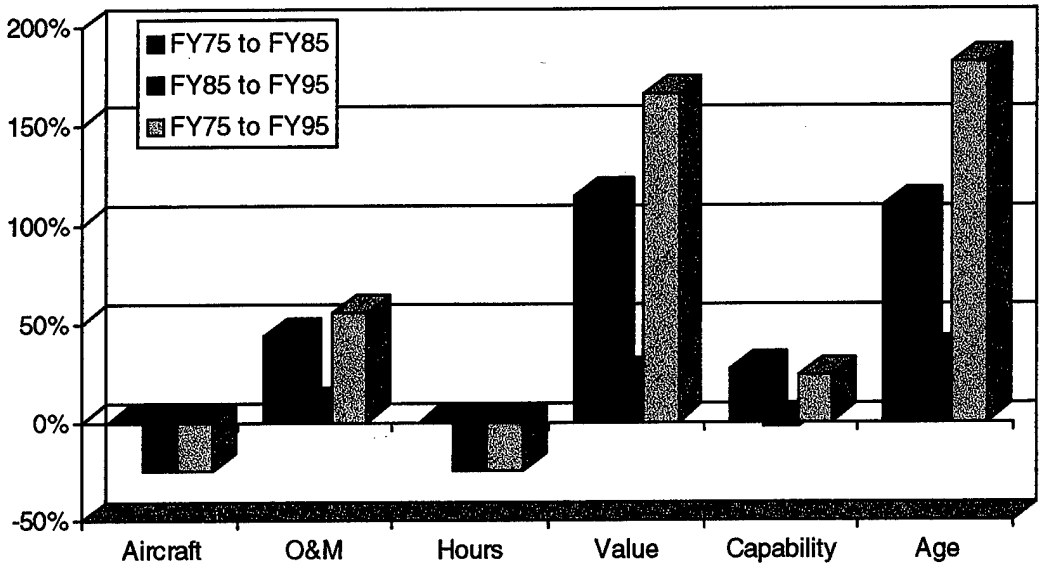

Figure II-11. Utility Helicopters
Total Resource and Performance Changes

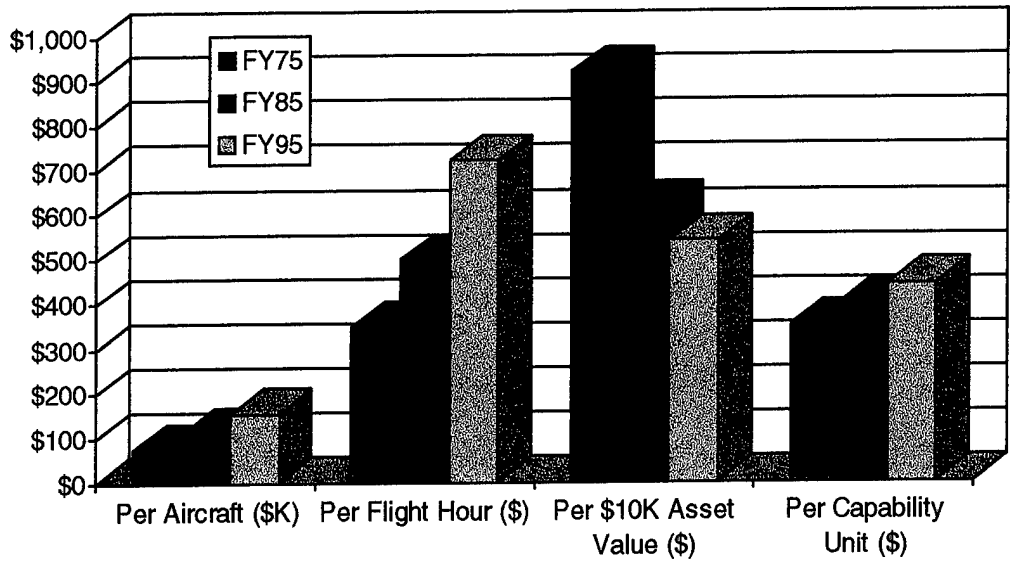

Figure II-12. Utility Helicopter O&S Cost Ratio Changes

The Army modernized its utility helicopters during this period and reduced the size of its fleet. Table II-14 focuses on Utility Helicopter inventories from Table II-13. Over 2,300 older UH-1 models were phased out during the period, and over 1,200 new UH-60s were introduced.

Table II-14. Utility Helicopter Modernization

Aircraft Type	FY75	FY95	Change
UH-1B	430	38	-392
UH-1H	3,322	1,688	-1634
UH-1M	309		-309
UH-1V	369	367	-2
UH-60A		926	926
UH-60L		316	316

Modernization has caused mission operating costs to increase. The annual operating cost figures for individual helicopters shown in Table II-15 indicate that the UH-1s are much cheaper to operate than the UH-60s.

The change in the mix of aircraft between FY 1975 and FY 1995 substantially accounts for the $186 million increase in O&M costs shown for utility helicopters in

Table II-13. In summary, the Army's experience in this mission area is typical of one in which moderate modernization has taken place during the 20-year period:

- O&M cost per flight hour is up, and
- O&M cost per unit of asset value is down.

However, in the case of utility helicopters, O&M cost per unit of capability is up.

Table II-15. Utility Helicopter Annual O&M Costs (FY 1996 $K)

Aircraft Type	O&M ($K)
UH-1H	54.0
UH-60A	194.0
UH-60L	305.0

C. CASE STUDIES

1. Tanks: M60A3 vs. M1A1

Comparative operating and support (O&S) cost and tank characteristic data are summarized in Table II-16 for the M60A3 and Abrams (M1A1) tanks.

Army active forces possessed over 90 percent of M1A1s in the FY 1990-94 period while virtually all of M60A3s were in the Army Guard and Reserve forces. To arrive at an M60A3 O&S cost figure comparable to the M1A1, we obtained M60A3 experience data for all cost elements except intermediate maintenance (IM) from operating and support management information system (OSMIS). These data were for the FY 1986 to FY 1991 time period when 78 percent of all M60A3 activity was in active force units. IM costs were not collected during that period. IM costs used here were based on the FY 1994 program total cost per mile for active components.

Total O&S costs for the M1A1 are 3.34 times O&S costs for the M60A3. End Item depot maintenance costs, for the M1A1 are more than 12 times that for the M60A3. Except for intermediate maintenance costs, which are less than half of the M60A3 value, all other costs elements showed significant increases.

The M1A1 is 20 to 30 percent larger and faster than the M60A3 and has a 120-mm main gun compared to the 105-mm main gun on the M60A3. The M1A1 also carries more machine guns. The asset value of the M1A1 is 55 percent higher than for the

M60A3. The M1A1 TASCFORM score, a measure of weapon system capability, is 69 percent higher than for the M60A3.

Table II-16. O&S Costs and Characteristics for Army Tanks (Cost Data In Constant FY 1996 Dollars)

Cost Element	M60A3	M1A1
Fuel	792	2,405
Ammunition	13,582	37,657
Consumables	4,198	21,649
Repairables (Net)	15,762	49,348
Intermediate Maintenance	915	389
Depot Maintenance (End Item)	500	7,899
Total Direct O&S Cost	35,749	119,347
Typical Miles Per Year (Active Duty)	500	500
O&S Cost Per Mile	71	239
Cost Ratio	1.00	3.34
Characteristics		
Combat Weight (tons)	57.3	67
Dimensions (feet)		
Length	31	32.25
Height	12	12
Top Speed (mph)	30	41.5
Powerplant	12-cylinder diesel	1,500-horsepower turbine
Fuel Capacity (Gallons)	375	504
Cruising Range (miles)	280	310
Crew	4	4
Armament		
Main Gun	105 mm	120 mm
Machine Guns	—	1.50 calibre
	1 7.62 mm	2 7.62 mm
	1 12.7 mm	1 12.7mm
Asset Value ($K)	$1,291	$2,003
TASCFORM Score	3.702	6.269

Sources: O&S cost data are from the Army OSMIS data base. M1A1 costs are based on experience data from FY 1990 to FY 1994. M60A3 costs are based on data from the FY 1986 to FY 1991 time period for all except intermediate maintenance, which is based on FY 1994 data. Cost per mile experience data were multiplied by 500, a typical utilization rate for tanks in the active force, to arrive at the annual costs shown in the table.

O&S costs for the M1A1 are 234 percent higher, asset value is 55 percent higher, and capability is 69 percent higher than for the M60A3. The faster growth in M1A1 O&S cost results in higher O&S cost per unit of asset value or capability than for the M60A3.

2. Attack Helicopters: AH-1S vs. AH-64A

Comparative O&S cost and helicopter characteristic data are summarized in Table 17 for the Cobra (AH-1) and Apache (AH-64A) attack helicopters.

Table II-17. O&S Costs and Characteristics for Attack Helicopters (Cost Data in Constant FY 1996 Dollars)

Cost Element	AH-1S	AH-64A
Fuel	8,648	10,220
Ammunition	38,532	7,497
Consumables	11,262	60,494
Repairables (Net)	150,352	326,922
Intermediate Maintenance	28,253	22,782
Depot Maintenance (End Item)	14,756	1,769
Annual Direct O&S Cost	251,803	429,685
Flight Hours Per Year	130	130
Direct O&S Cost Per Flight Hour	1,937	3,305
Cost Ratio	1	1.71
Characteristics		
Max TOGW (lbs.)	10,000	14,694
Empty Weight (lbs.)	6,598	11,387
Max Speed (knots)	133	158
Operating radius (miles)	369	300
Endurance (hours)	2.6	1.83
Fuel Capacity (gallons)	262	370
Crew	2	2
Asset Value ($M)	3.70	12.81
Capability (TASCFORM score)	3.182	10.47
Weapon Control	AWG-10	AWG-9
Armament	20-mm cannon	30-mm chain gun
	8 TOW missiles	Hellfire missiles
	76 2.75-in. rockets	Hydra 70 rockets

Sources: O&S cost data are from the Army OSMIS data base. AH-64A costs are based on experience data from FY 1990 to FY 1994. AH-1S costs are based on data from the FY 1986 to FY 1991 time period for all except intermediate maintenance, which is based on FY 1994 data. Cost per flight hour experience data were multiplied by 130, a typical utilization rate for utility helicopters in the active force, to arrive at the annual costs shown in the table.

From FY 1990 to FY 1994 most AH-1 utilization (57 percent) was in the Army Guard and Reserve forces while 75 percent of AH-64A utilization was for the active Army. AH-1 experience data from OSMIS (for all cost elements except IM) were obtained for the FY 1986 to FY 1991 time period, when 75 percent of AH-1S activity was for active force units. IM costs were not collected during that period. IM costs used here were based the FY 1994 program total cost per mile for active components.

Total O&S costs for the AH-64A are 71 percent higher than comparable costs for the AH-1S. Consumables and component repair (repairables) showed much larger than average increases while ammunition, intermediate maintenance, and depot end-item maintenance were less.

The AH-64A is larger, heavier, and faster than the AH-1S and has a more sophisticated armament and fire-control system. The asset value of the AH-64A is 246 percent higher than for the AH-1, and the TASCFORM score, a measure of weapon system capability, is 229 percent higher for the AH-64A. The AH-64's asset value and capability grew faster than its O&S cost, which results in a lower O&S cost per unit of asset value or capability than for the AH-1S.

3. Utility Helicopters: UH-1H vs. UH-60A

Comparative O&S cost and helicopter characteristic data are summarized in Table II-18 for the Huey (UH-1H) and Blackhawk (UH-60A) utility helicopters.

From FY 1990 to FY 1994 half of UH-1H utilization was in the Army Guard and Reserve forces, while 86 percent of UH-60A utilization was for the active Army. As in the previous two cases, we obtained UH-1H experience data for all cost elements except IM from OSMIS. These data were for the FY 1986 to FY 1991 time period, when 67 percent of UH-1H activity was in active force units. IM costs were not collected during that period. IM costs used here were based on the FY 1994 program total cost per mile for active components.

The UH-60A is more than twice the empty weight of the UH-1H, and it has the capability to carry twice as much cargo (externally loaded). The maximum speed is 145 knots compared to 107 for the UH-1H. The asset value of the UH-60A is 615 percent higher than for the UH-1H. The UH-60A is 172 percent higher in terms of ton-miles per hour, a measure of capability we used for cargo carrying non-combat vehicles.

O&S costs for the UH-60A are 177 percent higher, asset value is 615 percent higher, and capability is 172 percent higher than for the UH-1H. The UH-60's capability

grew at about the same rate as its O&S cost, which resulted in a similar O&S cost per unit of capability compared to the UH-1H. The UH-60's asset value grew faster than its O&S cost, which results in a lower O&S cost per unit of asset value.

Table II-18. O&S Costs and Characteristics for Utility Helicopters (Cost Data in Constant FY 1996 Dollars)

Cost Element	UH-1H	UH-60A
Fuel	9,104	11,542
Ammunition	259	576
Consumables	4,843	41,279
Repairables (Net)	43,782	182,925
Intermediate Maintenance	32,599	8,300
Depot Maintenance (End Item)	8,674	30,694
Annual Direct O&S Cost	99,261	275,316
Flight Hours Per Year	150	150
O&S Cost Per Flight Hour	662	1,835
Cost Ratio	1	2.77
Characteristics		
Max TOGW	9,500	22,000
Empty Weight	5,210	11,284
Max Speed (knots)	106.7	145
Combat radius (miles)	317	320
Fuel capacity (gallons)	209	362
Payload	4,000 lbs. external or 10 passengers	8,000 lbs. external 11 combat troops
Crew	3	3
Asset Value ($M)	$0.923	$6.600
Capability (Ton-miles per hour)	213.4	580.0
Armament	3 7.62-mm MGs	2 7.62-mm MGs

Sources: O&S cost data are from the Army OSMIS data base. UH-60A costs are based on experience data from FY 1990 to FY 1994. UH-1H costs are based on data from the FY 1986 to FY 1991 time period for all except intermediate maintenance, which is based on FY 1994 data. Cost per flight hour experience data were multiplied by 150, a typical utilization rate for attack helicopters in the active force, to arrive at the annual costs shown in the table.

III. DEPARTMENT OF THE NAVY

A. DEPARTMENTAL OVERVIEW

The Navy experienced a 2-percent increase in O&S costs between FY 1975 and FY 1995. O&M costs rose by 21 percent over that same period. Although the Navy reduced military personnel costs by 21 percent, those reductions did not fully offset the O&M increase. In the mission categories we studied, O&M costs often rose even as force levels dropped. Figure III-1 illustrates the divergence between force cuts and O&M changes.

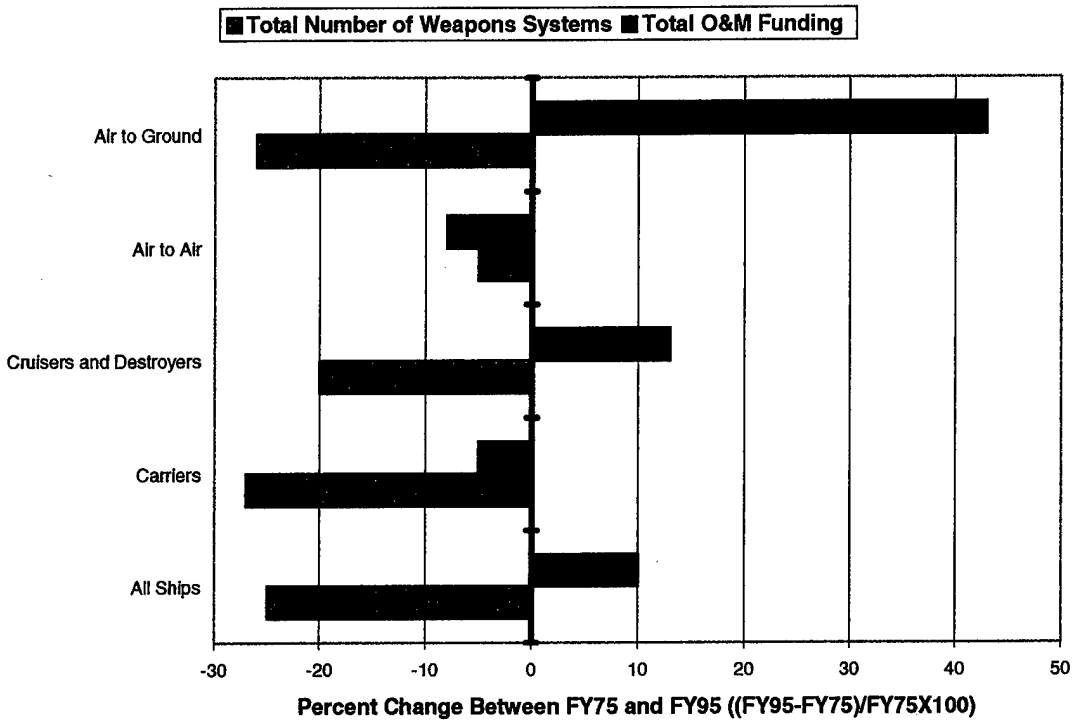

Figure III-1. Percent Change in Forces Compared to Percent Change in O&M

We expected to see a correlation between decreases in inventory and O&M funding such as that seen in the air-to-air mission category. In most categories with force

reductions, however, the O&M reduction is either small, or funding is increasing substantially.

We studied the five categories of Naval forces shown in Figure III-1 in an effort to understand why operating costs have gone up while forces declined. We found that between FY 1975 and FY 1995:

- **All combatant ships** were cut 25 percent but total O&M increased 10 percent. O&M per ship increased 47 percent.
- **Carriers** were cut 27 percent but total O&M dropped only 5 percent. O&M per ship increased 30 percent; steaming hours per ship increased 15 percent.
- **Cruisers and destroyers** were cut 20 percent and total O&M increased 13 percent. O&M per ship increased 50 percent; steaming hours per ship increased 34 percent.
- **Air-to-air** forces were reduced 5 percent but total O&M dropped 8 percent. O&M per aircraft dropped 3 percent; flying hours per aircraft dropped 35 percent.
- **Air-to-ground** forces were reduced 26 percent but total O&M increased 43 percent. O&M per aircraft increased 94 percent; flying hours per aircraft dropped 22 percent.

Table III-1 provides more details about these findings.

Table III-1. Percent Change in Selected Navy Mission Categories Between FY 1975 and FY 1995

Data Element	All Ships	Carriers	Cruisers and Destroyers	Air-to-Air	Air-to-Ground
Total Number of Weapons Systems	-25	-27	-20	-5	-26
Total O&M Funding	10	-5	13	-8	43
Total Military Personnel Pay	-8	4	-13	-33	-37
Total O&S	1	-0	-3	-20	-2
Total Steaming or Flying Hours		-15	6	-38	-43
Total Asset Value		-1	81	163	221
Total Capability Units		7	1,282	83	3
Average Age		16	-30	75	47
Steam or Fly Hours Per Weapon System		15	34	-35	-22
O&M Per Weapon System ($M)	47	30	50	-3	94
O&S Per Weapon System ($M)	34	36	22	-16	8
O&S Per Steaming or Flying Hour (K$)		17	-9	+29	70
O&S Per $10K Asset Value ($)		0	-46	-70	-70
O&S Per Capability Unit ($H)		-7	-93	-56	-5

We derived the O&M per weapon system figures in Table III-1 from the FYDP by dividing O&M for a ship type by the number of those ships. The results are usually higher than those derived from VAMOSC sources.

Figure III-2 shows VAMOSC O&M costs for ship classes within ship types for the mission areas we studied. We are missing some VAMOSC data for these comparisons. VAMOSC is a relatively new data system and we do not have FY 1975 data to compare with an equivalent number for FY 1995. Nevertheless, we can see from figure III-2 that the variation from class to class within ship type isn't usually very large.[1] This would lead us to expect that O&S costs should decrease in about the same proportion as ship inventory. Yet FYDP O&M costs have increased by 13 percent. This implies that the increase in mission-related costs is not directly associated with operating these ships.

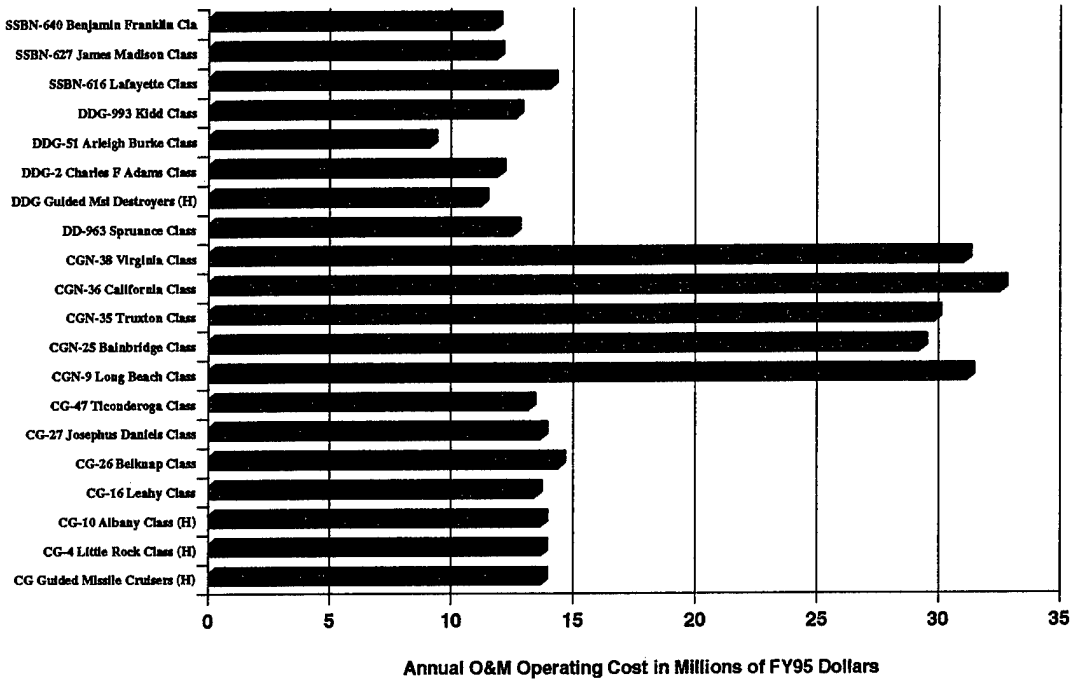

Figure III-2. Annual O&M Operating Costs by Ship Type and Class

1 DDG-51 costs, which appear low in Figure III-2, would be somewhat higher if estimated overhaul costs could be included in the cost as it is in the other DDG classes. The DDG-51 class is too new to have any substantial overhauls experience as yet.

To summarize, the Navy reduced the number of weapons systems in four of the five studied categories from 20 to 30 percent between FY 1975 and FY 1995. The exception is air-to-air forces aircraft, which were trimmed by only 5 percent. Steaming hours per ship increased and flying hours per aircraft decreased. O&M cost per weapons system increased substantially for ships (30 percent for carriers, 50 percent for cruisers and destroyers) and ranged from a small decrease (3 percent for air-to-air systems) to a large increase for aircraft (94 percent for air-to-ground systems).

B. MISSION CATEGORY REVIEW

1. Analysis of All Combatant Ships

In our search for the causes of the O&M increase, we first looked at what happened to the numbers and kinds of ships operated by the Navy. Figure III-3 shows how ship profiles changed during the FY 1975-1995 time period. We found that the number of ships dropped from 496 to 374 between FY 1975 and FY 1995, a 25-percent reduction of the fleet. However, despite the drop, O&S costs rose slightly, and O&M costs rose by more than 10 percent. Figure III-4 shows how ship cost profiles changed.

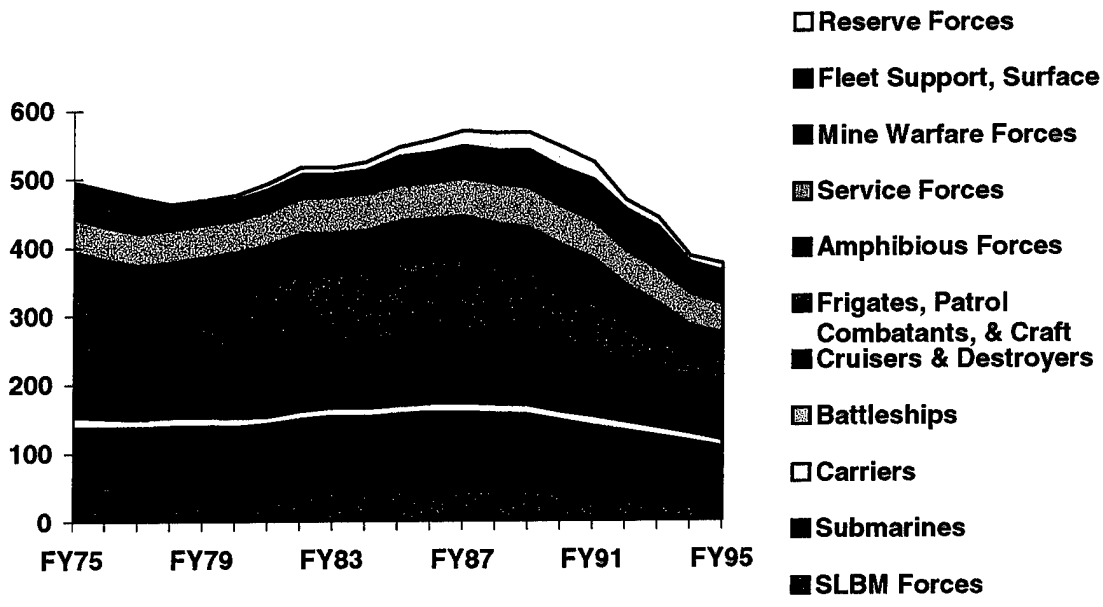

Figure III-3. Navy Battle Forces Ships

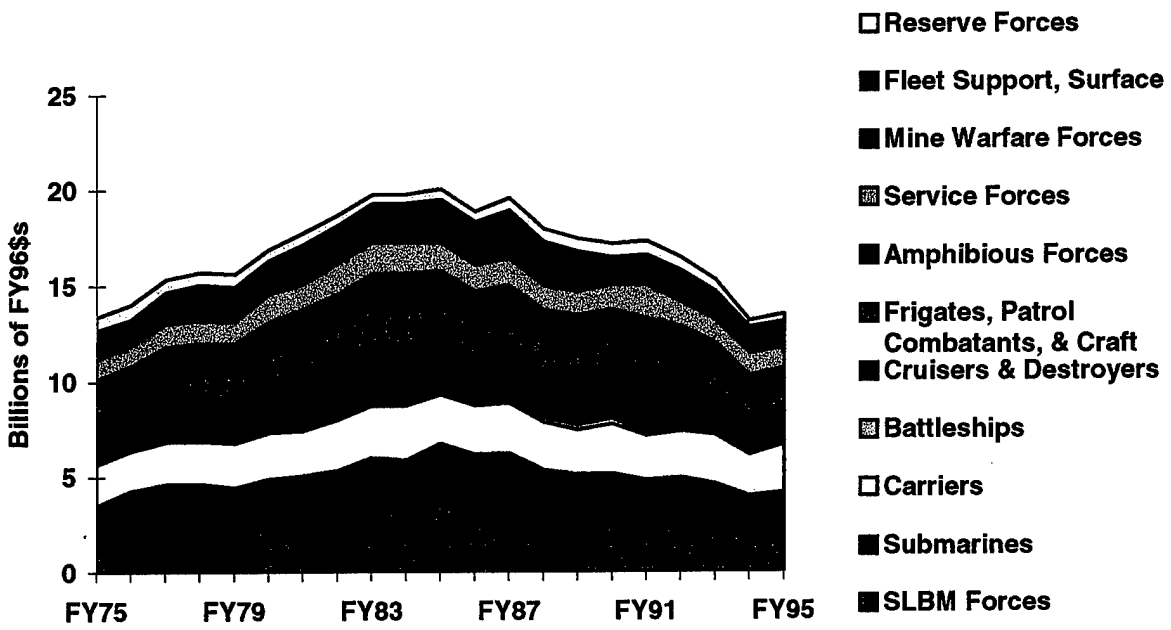

Figure III-4. Navy Battle Forces Ship O&S Costs

Overall ship O&S costs rose $0.1B during the period to stand at $13.5B in FY 1995 while, at the same time, O&M costs rose $0.7B to stand at $7.1B. Since cost increased while the number of ships decreased, we needed to identify which ships were increasing in average costs, which ones were staying the same, and which ones were decreasing, if any. To do this, we derived the annual operating cost per ship type using FYDP program element data. Figure III-5 shows the results of that inquiry; substantial cost increases in all ship types except Mine Warfare Forces.

Next we wanted to see how modernization changed the mix of ships during the FY 1975-95 period. Table III-2 shows how ship classes change within ship types for SLBMs, Submarines, Carriers, Cruisers and Destroyers, and Mine Warfare. This table points out that new classes have replaced substantial numbers of their aging predecessors in all ship types. It is also important to note that half of the ship types, not counting support ships, show increased numbers in FY 1995 compared to their FY 1975 level.

SLBMs, which had the largest cost increase per ship, also had the largest reduction in the number of ships. Of course submarine classes are very different and it is thought that this mission area has substantial fixed costs. Table III-3 shows the annual O&M operating cost of strategic submarines we derived from the Navy's VAMOSC data system, a non-FYDP data source.

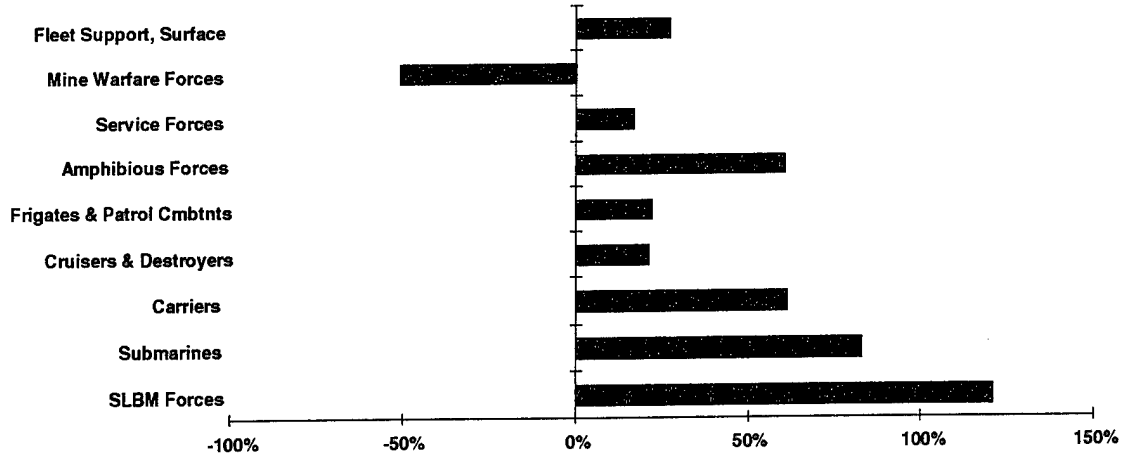

Figure III-5. Percent Change in O&S Cost Per Ship

Table III-2. Changes in Selected Ship Forces

	FY75	FY95	Forces
SLBM	41 Polaris	16 Trident	-61.0%
Support Ships	9	0	-100.0%
Submarines	11 SS, 62 SSN	84 SSN	15.1%
Support Ships	15	7	-53.3%
Carriers	13 CV, 2 CVN	4 CV, 7CVN	-26.7%
Cruisers	22 CG, 5 CGN	27 CG-47, 5 CGN	18.5%
Destroyers	38 DDG, 32 DD	15 DDG, 31 DD	-34.3%
Mine Warfare	3 MSO	12 MCM,3 MSH	400.0%

Table III-3. Strategic Submarine Annual O&M Costs (FY 1996 $M)

Type and Class	O&M
SSBN-616 Lafayette Class	14.0
SSBN-627 James Madison Class	11.8
SSBN-640 Benjamin Franklin Class	11.7

Table III-3 data point out that the more modern classes of strategic submarines require no more O&M funding than the older classes.

At this point in the analysis, we cannot say that increased operating costs of any type or class ship is driving up costs. While a ship is generally the most expensive weapon

in a mission area, there are, nevertheless, other programs that contribute to a mission area's overall expense. Furthermore, a ship's activity rate (steaming hours per year) is subject to change over time, going up when the senior leadership is seeking to increase readiness and down when cost savings are more important. We will find some answers to the paradox posed by Table III-3 and Figure III-5 as we investigate a number of these mission areas more thoroughly in the next section.

2. Analyses by Defense Mission Category (DMC)

For the Navy's mission category review, we chose to look more deeply into two elements of the Naval Forces Surface Combatants DMC and another two within the Navy Tactical Air Forces DMC. Figure III-6 shows the O&S trends in these two areas.

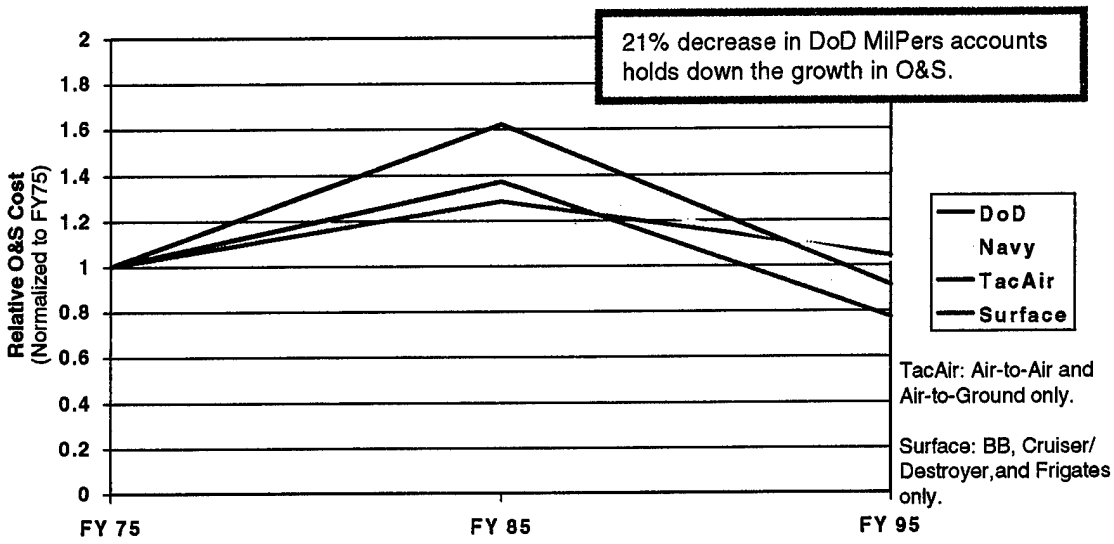

Figure III-6. O&S Trends in Selected Tactical Air and Surface Combatant Missions

Notice that the O&S experience for the selected Tactical Air Forces missions and Surface Combatants are substantially less than the overall Navy and DoD figures. Figure III-7 shows the results for O&M only.

Selected Navy Tactical Air Forces missions O&M grew 13 percent by FY 1995 relative to FY 1975 whereas the Selected Surface Combatants O&M dropped by 12 percent by FY 1995. To understand why, we will take a look at the underlying data in each of these areas. We will begin with the carriers.

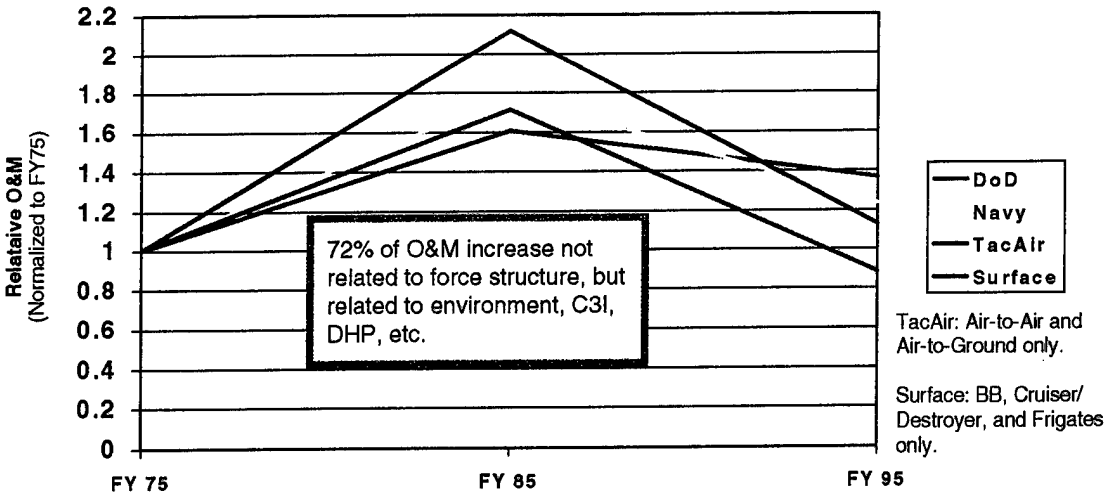

Figure III-7. O&M Trends in Selected Tactical Air and Surface Combatant Missions

3. Carriers

Table III-4 contains all of the basic data we collected for this mission area.

Table III-4. Carrier Mission Data (Cost Data in Constant FY 1996 Dollars)

Data Element	FY75	FY85	FY95
Carriers	15	13	11
O&S ($M)	$2,525	$3,172	$2,523
O&M ($M)	1,209	1,843	1,150
Military Personnel ($M)	1,316	1,329	1,373
Steaming Hours	39,708	42,363	33,624
Asset Value ($M)	31,571	32,339	31,387
Capability Index	40,159	44,592	43,052
Average Age	18.6	23.1	21.6
Aircraft	16	1	0
Flying Hours	8,411	341	0
Average Age (A/C)	18.5	27.9	0.0
O&S Per Carrier ($M)	168	244	229
O&S Per Steaming Hour (K$)	64	75	75
O&S Per $10K Asset Value ($)	800	981	804
O&S Per Capability Unit ($H)	629	7	586

Table III-4 shows that the:

- Number of carriers is reduced by over 25 percent and
- Total steaming hours is decreased by 15 percent, yet

- Total O&S cost of the carrier fleet remains the same and
- Total O&M is reduced by only 5 percent.

As a result, average O&S cost per carrier increases by over 36 percent and average O&S cost per steaming hour increases by 17 percent.

Now let's look at these data in standard chart form. Turning first to Figure III-8, we find that changes in total O&S, number of carriers, and total steaming hours are as expected. The lack of change in total asset value is consistent with a small force of more expensive (to buy) ships equaling the cost of an older but larger fleet of cheaper ships. The increase in capability is not surprising since a more modern fleet of ships could easily have more capability.

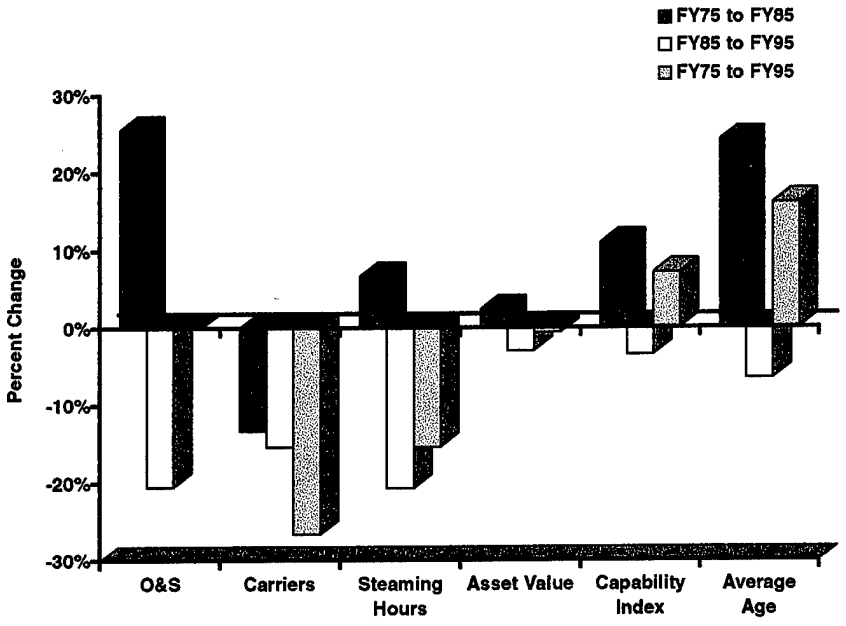

Figure III-8. Carrier Mission Total Resources and Performance Changes

Figure III-9 shows the values for each carrier O&S cost ratio. O&S cost per carrier and per steaming hour have both increased while O&S cost per unit of asset value has stayed the same and O&S per unit of capability has dropped slightly.

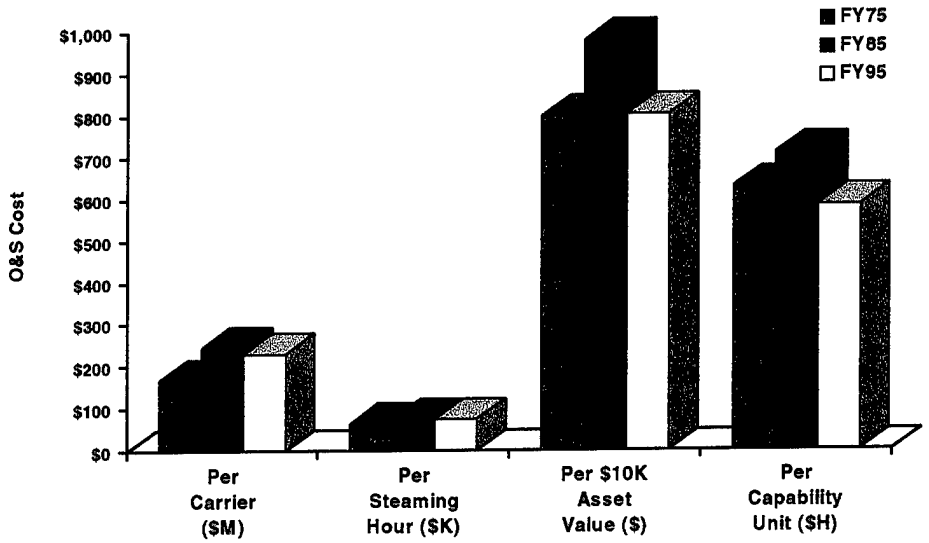

Figure III-9. Carrier Mission O&S Cost Ratio Changes

How has modernization affected the weapons inventory of this mission area? Referring back to Table III-2, we find that carrier modernization has been substantial during this period, specifically,

- CVs decrease from 13 to 4, and
- CVNs increase from 2 to 7.

How has modernization changed mission operating costs? The annual operating cost figures for individual carrier types and classes in Table III-5 show that the more modern carriers generally use less O&M than the older versions.

Table III-5. Multi-Purpose Aircraft Carriers (FY 1996 $M)

Type & Class	O&M
CV 41 Midway Class	83.9
CV 59 Forrestal Class	80.0
CV 63 Kitty Hawk Class	91.4
CV 67 John F Kennedy Class	75.0
CVN 65 Enterprise Class	72.5
CVN 68 Nimitz Class	64.0

Part of this reduction is an accounting aberration, since neither the CVN figures nor the total O&M figures include the cost of nuclear fuel. Nevertheless, the visible cost of carrier operations in the O&M appropriation has decreased. But did it decrease the appropriate amount? In fact, it seems that the cost of carrier operations should have decreased more; however,

- These savings appear to be substantially offset by an increase in the average steaming hours per carrier.
- In FY 1975, a total of 39,708 steaming hours was allocated among 15 carriers to produce an average of 2,647 steaming hours per carrier.
- In FY 1995, a total of 33,624 steaming hours was allocated among 11 carriers to produce an average of 3,057 steaming hours per carrier, an increase of approximately 15 percent.

It appears that steaming hours per carrier were increased, perhaps in part, to offset readiness and regional capability losses brought about by the retirement of four carriers. Regardless of the rationale, the increased steaming hours per carrier offset a substantial amount of the O&M savings expected from the retirements.

4. Cruisers and Destroyers

Table III-6 contains all of the basic data we collected for this mission area.

Table III-6. Cruisers and Destroyers Mission Data (Costs Data in Constant FY 1996 Dollars)

	FY75	FY85	FY95
Cruisers & Destroyers	98	98	78
O&S ($M)	2,058	2,758	1,998
O&M ($M)	805	1,462	910
Military Personnel ($M)	1,253	1,296	1,088
Steaming Hours	212,769	266,264	226,144
Asset Value ($M)	37,489	56,133	67,966
Capability Index	1,965	5,658	27,152
Average Age (Ships)	16.0	15.4	11.2
O&S Per Ship ($K)	20,997	28,148	25,619
O&S Per Steaming Hour ($)	9,671	10,360	8,836
O&S Per $100K Asset Value ($)	5,489	4,914	2,940
O&S Per Capability Unit ($H)	10,474	4,875	736

The Navy reduced the number of ships classified as cruisers and destroyers by 20 percent between FY 1975 and FY 1995, but their total steaming hours were increased by

6 percent. While total O&S costs dropped by only 3 percent, O&M increased by 13 percent and military personnel costs dropped by 13 percent. As a result, average O&S cost per ship increased by 22 percent and average O&S cost per steaming hour decreased by 9 percent.

Figure III-10 shows the changes in total cruiser and destroyer data. Changes to total O&S, the number of ships, and total steaming hours are unremarkable. Total asset value explodes with a dramatic 81-percent increase, and capability increases by an astonishing 1,282 percent. This very high capability increase is generated in large measure by the introduction of the AEGIS system and vertical launch capability on the CG-47.

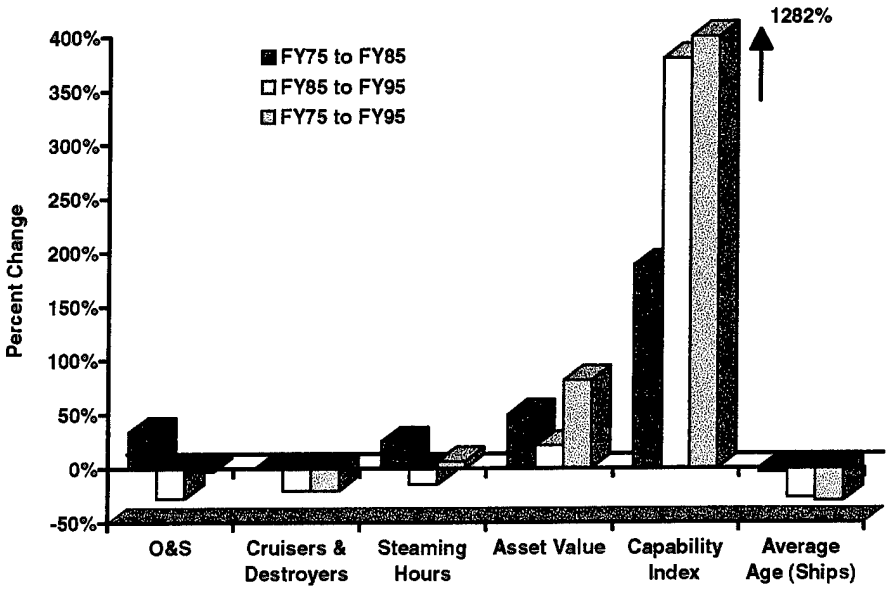

Figure III-10. Cruisers and Destroyers Mission Total Resources and Performance Changes

Figure III-11 shows the values for each cruiser and destroyer cost ratio. O&S cost per ship increased by 22 percent, and O&S per steaming hour decreased by 9 percent. O&S cost per unit of asset value dropped by 46 percent, and O&S per unit of capability dropped 93 percent.

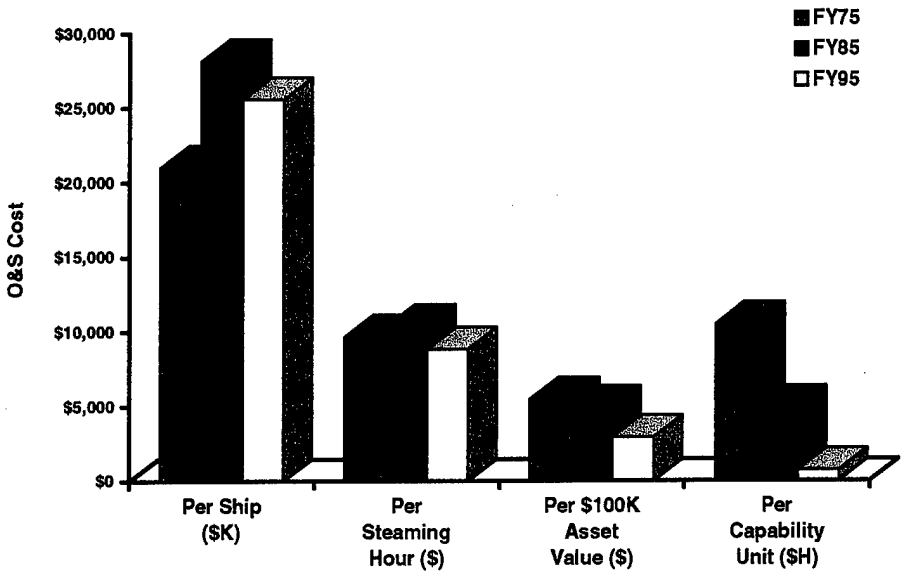

Figure III-11. Cruisers and Destroyers Mission O&S Cost Ratio Changes

Cruiser and destroyer classes have had substantial modernization during this period. Table III-7 focuses on cruiser and destroyer class inventories from Table III-2. The CGNs and DDs are the only two classes that have remained unchanged during the FY 1975-95 period. The CGs have been completely replaced by the CG-47s and the DDGs have been reduced by 60 percent.

Table III-7. Number of Cruisers and Destroyers

Type and Class	FY75	FY95
CG	22	0
CGN	5	5
CG-47	0	27
DDG	38	15
DD	32	31

Modernization has reduced mission operating costs somewhat. The annual operating cost figures in Table III-8 show that the CGs and CG-47s have about the same annual O&M cost, and the DDG-51s are about 20 percent cheaper than the DDG-2s.

Table III-8. Cruisers and Destroyers Annual O&M Costs (FY 1996 $M)

Type and Class	O&M
CG Guided Missile Cruisers (H)	13.6
CG-4 Little Rock Class (H)	13.6
CG-10 Albany Class (H)	13.6
CG-16 Leahy Class	13.4
CG-26 Belknap Class	14.3
CG-27 Josephus Daniels Class	13.6
CG-47 Ticonderoga Class	13.1
CGN-9 Long Beach Class	31.1
CGN-25 Bainbridge Class	29.2
CGN-35 Truxton Class	29.8
CGN-36 California Class	32.5
CGN-38 Virginia Class	31.0
DD-963 Spruance Class	12.5
DDG Guided Missile Destroyers (H)	11.2
DDG-2 Charles F Adams Class	11.9
DDG-51 Arleigh Burke Class[2]	9.1
DDG-993 Kidd Class	12.6

Note: Annual O&M Cost, FY 1996 ($M) Navy VAMOSC Compilations.

However, for this mission area, acquiring an additional 5 CG-47s should have added about $55 million in annual O&M operating costs, and retiring 23 DDG-2s should have saved a little over $275 million per year in O&M operating costs. This nets out to about $220 million in annual savings. However, Table III-6 shows that cruiser and destroyer O&M costs have increased by $105 million, a 13-percent increase.

It appears that the savings have been substantially offset by an increase in the average steaming hours per destroyer or cruiser.

- In FY 1975, a total of 212,769 steaming hours was allocated among 98 ships to produce an average of 2,171 steaming hours per ship.
- In FY 1995, a total of 266,264 steaming hours was allocated among 78 ships to produce an average of 2,899 steaming hours per ship, an increase of approximately 34 percent.

Again, it appears that per ship steaming hours may have been increased to offset readiness and regional capability losses brought about by the retirement of 20 ships. No

2 DDG-51 costs, which appear low in Table III-8, would be somewhat higher if estimated overhaul costs could be included in the cost as it is in the other DDG classes. The DDG-51 class is too new to have any substantial overhauls experience as yet.

matter what the reason, the increased steaming hours per ship offset a substantial amount of the saving expected from the retirements.

5. Air-To-Air Combat

Table III-9 contains all of the basic data we collected for this mission area.

Table III-9. Active Air-to-Air Combat Mission Data (Cost Data in Constant FY 1996 Dollars)

	FY75	FY85	FY95
Aircraft	183	219	174
O&S ($M)	$500	$766	$400
O&M ($M)	251	525	232
Military Personnel ($M)	249	241	168
Flying Hours	68,800	94,020	42,679
Asset Value ($M)	3,416	10,444	8,978
Capability Index	2,989	6,430	5,465
Average Age	7.3	7.9	12.8
O&S Per Aircraft ($K)	2,734	3,496	2,298
O&S Per Flight Hour ($)	7,273	8,144	9,367
O&S Per $10K Asset Value ($)	1,465	733	445
O&S Per Capability Unit ($H)	1,674	1,191	732
Equipment Data	38 F-8J	20 F-4S	116 F-14A
	61 F-4J	199 F-14A	24 F-14B
	34 F-4N		34 F-14D
	50 F-14A		

In Table III-9, notice that between FY 1975 and FY 1995:

- The total number of aircraft dropped less than 5 percent while flying hours dropped 38 percent.
- There is a 20-percent decline in total O&S. It was reached by cutting
  - Over 32 percent out of military pay, and
  - Less than 8 percent out of O&M costs.
- Asset Value increased by 163 percent and mission capability increased by 83 percent. This was caused by the change over from F-4s to F-14s, which had begun in FY 1975 and was completed sometime after FY 1985 but before FY 1995.

These data are shown graphically in Figure III-12.

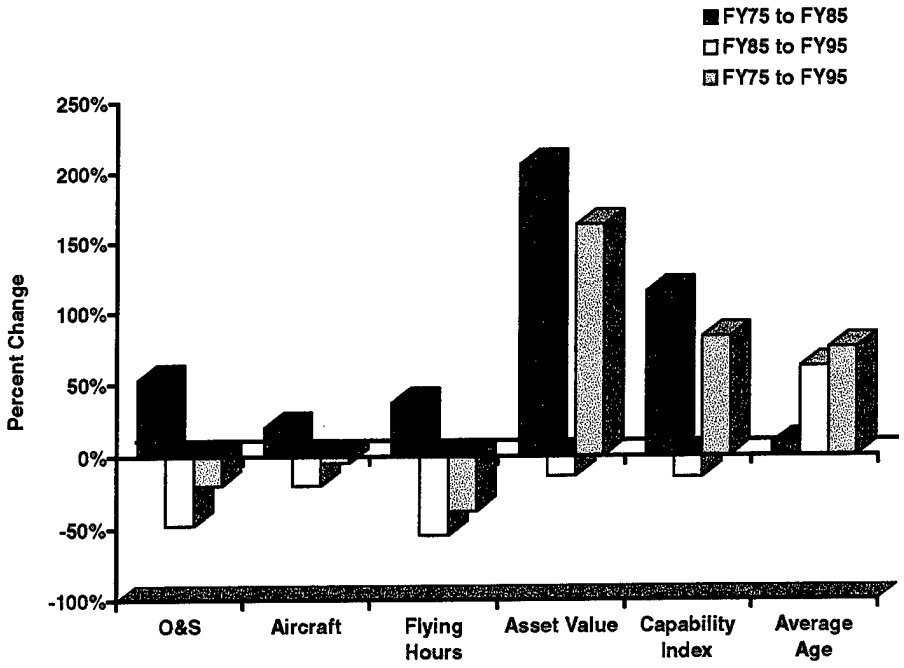

Figure III-12. Active Air-to-Air Combat Mission Total Resource and Performance Changes

Looking at the "per unit" section of the Table III-9, we see that between FY 1975 and FY 1995, O&S cost:

- Per aircraft decreased by 16 percent,
- Per flying hour increased by 29 percent,
- Per $10K of Asset Value dropped by 70 percent, and
- Per unit of capability dropped by 56 percent.

Figure III-13 shows these data in chart form.

In summary, the Navy's O&S experience in the active air-to-air mission area is typical of one in which substantial modernization has taken place during the 20-year period:

- O&S cost per flight hour is up,
- O&S cost per unit of asset value is down,
- O&S cost per unit of capability is down, and
- O&S cost per aircraft has been reduced by cutting flying hours.

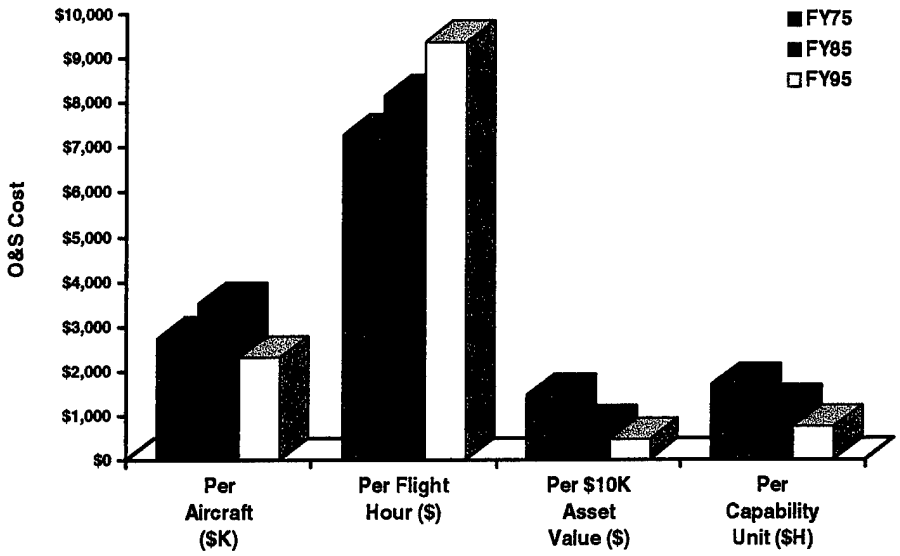

Figure III-13. Active Air-to-Air Combat Mission O&S Cost Ratio Changes

However, the net impact of these facts has produced an unusually large O&S reduction. In this mission area, the Navy achieved a reduction in O&S costs that is substantially larger than the reduction in the force structure, even with the cost increases due to modernization. This is possible because the increased costs of modernization were largely offset by a 32-percent reduction in flying hours.

6. Air-to-Ground Combat

Table III-10 contains all of the basic data we collected for this mission area. In Table III-10 we see the following important changes between FY 1975 and FY 1995:

- The total number of aircraft dropped approximately 26 percent; but flying hours dropped 43 percent;
- There was a 2-percent decline in total O&S. It was reached by:
  - Cutting over 37 percent out of military pay, and
  - Adding 43 percent to O&M costs.

- Asset Value increased by 221 percent and mission capability increased by 3 percent.[3] The increase in asset value is the result of retiring all A-4s, A-7s, and two-thirds of the A-6s, coupled with acquiring 256 F/A-18s. The capability increase looks small because the total number of aircraft dropped by 26 percent.

Table III-10. Active Air-to-Ground Combat Mission Data (Cost Data in Constant FY 1996 Dollars)

	FY75	FY85	FY95
Aircraft	477	369	352
O&S ($M)	$708	$1,073	$693
O&M ($M)	311	700	444
Military Personnel ($M)	397	374	249
Flying Hours	190,812	168,756	109,426
Asset Value ($M)	3,426	4,782	11,003
Capability Index	6,791	6,547	7,004
Average Age	6.0	12.1	8.8
Per Aircraft ($K)	1,484	2,908	1,969
Per Flight Hour ($)	3,710	6,360	6,333
Per $10K Asset Value ($)	2,067	2,244	630
Per Capability Unit ($H)	1,042	1,639	989
A-4	42		
A-6	135	148	96
A-7	300	189	
F/A-18		32	256

Figure III-14 shows these data in chart form.

In the "per unit" section of the Table III-10, we see that between FY 1975 and FY 1995, O&S cost:

- Per aircraft increased by 33 percent,
- Per flying hour increased by 71 percent,
- Per $10K of Asset Value dropped by 70 percent, and
- Per unit of capability dropped by 5 percent.

Figure III-15 shows these data in chart form.

[3] The capability unit measurement requires some explanation. Because the F/A-18 is a dual-role aircraft and the A-4, A-6, and A-7 are optimized for the ground-attack role only, we elected to score the F/A-18 with the average of its scores for the air-to-air and air-to-ground missions. This resulted in a somewhat higher score than if only the air-to-ground score for the F/A-18 were used, since the F/A-18 scored somewhat higher in its air-to-air role.

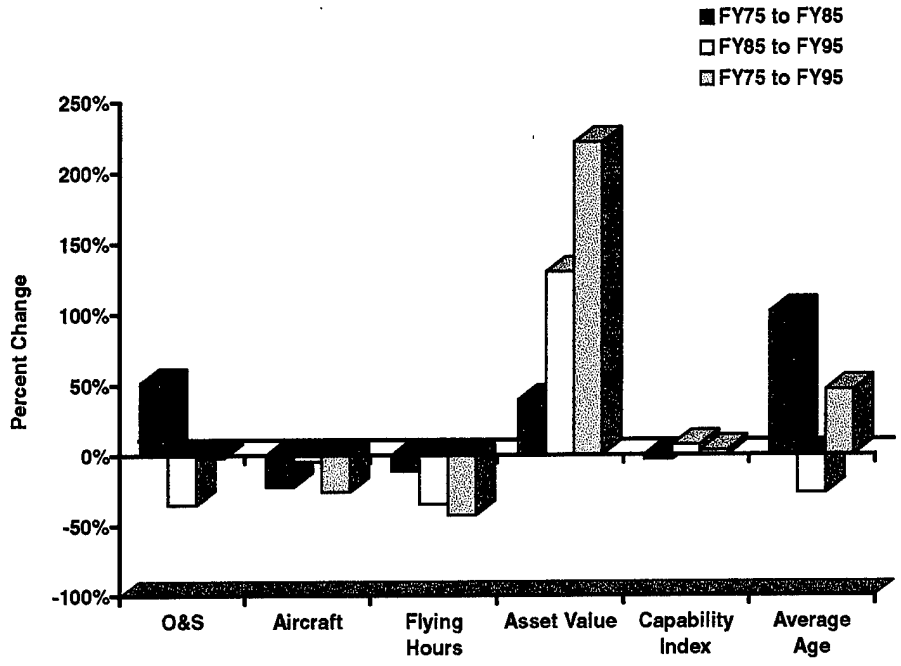

Figure III-14. Active Air-to-Ground Combat Mission Total Resources and Performance Changes

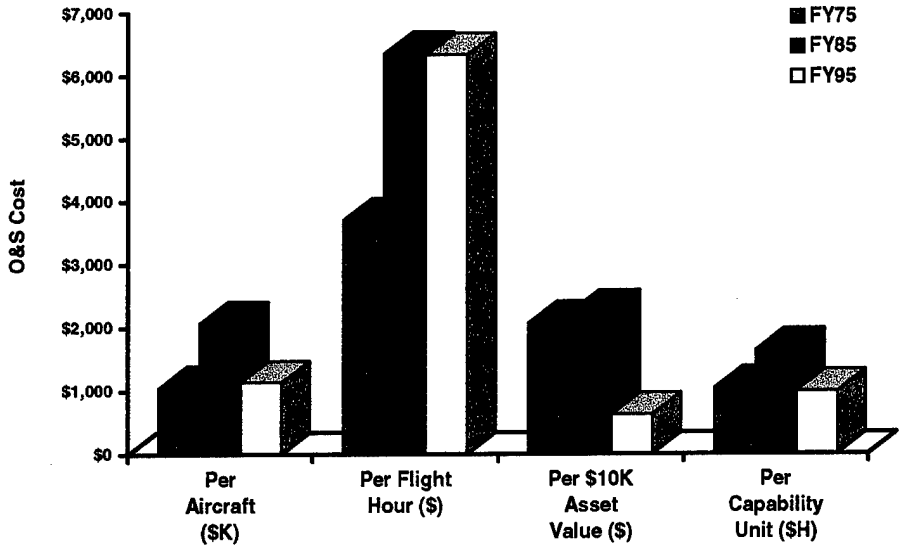

Figure III-15. Active Air-to-Ground Combat Mission O&S Cost Ratio Changes

In summary, the Navy's O&S experience in the active air-to-ground mission area is typical of one in which substantial modernization has taken place during the 20-year period:

- O&S cost per flight hour is up,
- O&S cost per unit of asset value is down,
- O&S cost per unit of capability is down, and
- O&S cost per aircraft has been held down by reducing flying hours.

In this mission area, the Navy achieved a reduction in O&S costs that is substantially less than the reduction in the force structure. The increased costs of modernization were partially offset by a 43-percent reduction in flying hours.

D. CASE STUDIES

1. DDG-2 vs. DDG-51

Comparative ship characteristic and operating and support cost data are summarized in Tables III-11 and III-12 for the Charles Adams class (DDG-2) and the Arleigh Burke class (DDG-51) guided-missile destroyers.

Table III-11. Comparative Characteristics Data for DDG-2 and DDG-51 Classes

Ship Characteristics	DDG-2 Class	DDG-51 Class
Full Load Displacement (tons)	4,500	8,300
Dimensions (feet)		
Length	437	466
Beam	47	59
Draft	20	21
Speed (knots)	35	31
Officer Crew	22	22
Enlisted Crew	321	305
Radar	SPG-51D	SPY-1D
Radar Peak Power	200 KW	4 to 6 MW
SAM Launcher	MK13 Magazine	MK41 VLS
Rate of Fire (Surface-to-Air Missiles)	6 to 8 per minute	N/A
Armament - AAW	Tartar/Standard	Standard
ASW	ASROC/Torpedos	ASROC/Torpedos
ASUW	Standard SSM	Harpoon/TASM
Strike	Standard SSM	TLAM
Asset Value ($Ms)	$310	$894
TASCFORM Score	5.02(FY75)-11.52(FY85)	80.96(FY95)

Table III-12. Comparative O&S Cost Data for DDG-2 and DDG-51 Classes (Cost Data in Constant FY 1996 Dollars)

Per Ship Costs	DDG-2 Class	DDG-51 Class
Crew Pay ($K)	8,640	9,168
Fuel ($K)	6,315	3,203
Other Ship Direct Operating ($K)	3,345	4,186
Intermediate Maintenance ($K)[a]	277	125
Depot Maintenance ($K)[a]	8,323	1,497
Indirect O&S	492	874
Total Direct O&S Cost ($K)[a]	27,393	18,179
Steaming Hours Per Year (Average 1984-88)	2,466	2,531
O&S Cost Per Steaming Hour ($)[a]	11,108	7,183

[a] Insufficient DDG-51 data available. The class is too new to accurately establish intermediate or depot maintenance costs based on experience data; costs are the average of 3 years of data for the lead ship.

The DDG-2 class destroyer had 23 ships commissioned between 1960 and 1964. The operating and support costs for this class were $27.4 million per year or $11,108 per underway steaming hour in FY 1996 constant dollars, based on data from the Navy's VAMOSC O&S cost reporting system.

Twenty-eight DDG-51 class destroyers are planned to be commissioned by 1999. The lead ship was commissioned on July 4, 1991. This is the only ship of this class with 3 years of O&S cost history that can be used for comparison to DDG-2 O&S costs. Not enough cost experience data exists on this class to reliably establish intermediate or depot maintenance costs. The same comment, therefore, applies to total O&S costs. Even though the DDG-51 is 1.8 times the full-load displacement of the DDG-2, the crew size is 5 percent less than that of the DDG-2. Fuel cost is less for the DDG-51, while other ship O&S costs are higher than comparable costs for the DDG-2.

The DDG-51 Arleigh Burke class AEGIS destroyers are equipped with the Tomahawk, Harpoon, SM-2 SAM, ASROC, and Mk46 Torpedoes. The DDG-51 has the SPY-1D phased-array radar (four faces per ship with peak power in the 4-to-6 MW range) and the Vertical Launch System with 90 launch tubes. SH-60 LAMPS ASW helicopter can be refueled and rearmed on the rear deck of the DDG-51.

The DDG-2 Charles Adams class guided-missile destroyers are equipped with the Tartar SAM, Standard Missiles, ASROC, and ASW Torpedoes. The DDG-2 uses the SPG-51D fire control system with dish-type SPS-10 and SPS-40 search radars (SPS-40 peak power is 200 KW with scan rates of 7.5 or 15 rpm). The MK13 Magazine Style missile launcher is capable of launching 6 to 8 missiles per minute.

The TASCFORM score of the DDG-51 is 16.1 times that of the DDG-2 in 1975 and 7.0 times the improved DDG-2 configuration in 1985. This is mainly due to the higher power and phased-array design of the AEGIS radar, the fire control system which permits the reliable simultaneous tracking and engagement of multiple targets, and the Vertical Launch System (VLS), which has a much higher maximum rate of fire than the MK13 Magazine Style Missile Launcher. The VLS is also much less vulnerable to a launcher jam or other reliability failure. The DDG-51 uses 1990s versions of the Standard, Tomahawk, and Harpoon missiles.

Unit asset value for the DDG-51 is 2.9 times that of the DDG-2. While there is insufficient data to establish the actual intermediate maintenance, depot maintenance, or total direct O&S costs for the DDG-51, it appears that direct O&S costs will be less than 50 percent higher than direct O&S costs of the DDG-2. If this is true, then the ratio of DDG-51 O&S cost to asset value supported will be about half the comparable ratio for the DDG-2. The ratio of DDG-51 O&S cost to the TASCFORM capability score will be about one-tenth the comparable ratio for the DDG-2.

When sufficient operating cost experience data on the DDG-51 is available, we expect the O&S cost per ship to be approximately equal to DDG-2 O&S costs on a per unit basis. However, considering that the DDG-51 is 1.8 times the size, almost 3 times the construction cost,and 7.0 to 16.1 times as capable as the DDG-2, our current view is that DDG-51 O&S costs appear reasonable and show the effects of lower operating and maintenance requirements achieved through incorporating higher reliability subsystems and task automation in the advanced ship design phase.

2. F-4 vs. F-14

The carrier-based fighter aircraft in FY 1975 were the F-4J and F-4S. These were replaced by the F-14. Both fighters had a maximum speed greater than Mach 2. The F-14 is larger and has greater payload carrying capacity with greater installed total engine thrust than the F-4. Maximum gross weight is 20 percent higher and installed thrust is 29 percent higher in the F-14. Comparative aircraft characteristic data and O&S costs are shown in Tables III-13 and III-14, respectively. Figure 16 compares each follow-on aircraft to its predecessor.

Table III-13. Comparative Characteristic Data for Fighter and Attack Aircraft (Costs In Constant FY 1996 Dollars)

VAMOSC Cost Elements	F-4J	F-14A	A-6E	A-7E	F/A-18A	F/A-18C
Max TOGW	61,795	74,348	60,400	41,912	56,000	56,000
Empty Weight	30328	39,921	26,747	19,048	23,832	23,832
Max Speed	M2+	M2.34	541kt@SL	600kt@SL	M1.7+	M1.7+
Thrust (lbs. per aircraft)	35,800	46,200	18,600	15,000	35,200	35,200
Asset Value ($M)	8.8	51.6	15.8	7.3	37.1	37.1
Capability (TASCFORM score)	12.17	27.22	11.5	10.2	19.35	19.8

Table III-14. Comparative O&S Cost Data for Fighter and Attack Aircraft (Cost Data in Constant FY 1996 Dollars)

VAMOSC Cost Elements	F-4J	F-14A	A-6E	A-7E	F/A-18A	F/A-18C
Organizational	1,508	1,438	1,629	1,197	1285	1,396
Intermediate	327	118	176	126	236	145
Depot Support	114	362	502	157	139	137
Training Support	150	375	499	223	152	199
Recurring Investment	20	172	472	11	23	25
Other Functions	29	22	23	18	19	16
Annual Direct O&S Cost ($K)	2,147	2,488	3,301	1,731	1,853	1,918
Flight Hours Per Year	223	264	311	307	312	384
Direct O&S Cost Per Flight Hour ($)	9,628	9,424	10,604	5,643	5,949	4,993
Fuel Cost Per Flight Hour ($)	2,805	1,136	1,462	514	1,006	939

Source: All aircraft O&S cost data are from the Navy's VAMOSC data system. For F-14A, F/A-18A and F/A-18C, 5-year average experience data (FY 1990 to FY 1994) are used. A-6E and A-7E O&S costs are a 5-year average (FY1987 to FY1991). F-4J O&S costs are a 3-year average (FY 1987 to FY 1989).

The F-14 is equipped with the AWG-9 fire control system capable of tracking 24 targets and engaging up to 6 targets simultaneously. The F-14 could be loaded with Sparrow (AIM-7), Phoenix (AIM-54), and/or Sidewinder (AIM-9) air interdiction missiles, and, beginning in 1993, the HARM defense radar suppression missile. The F-14 could also carry a variety of air-to-ground missiles and conventional bombs.

The F-4J or F-4S carrier-based models had the AWG-10 fire control system. The F-4s also could be loaded with the Sparrow or Sidewinder missiles and conventional bombs.

Figure III-16 graphically summarizes the comparison of the F-14A to the F-4J data in several categories. Each vertical bar shown is the F-14A value relative to the F-4J (i.e., F-4J = 1.0).

The comparative O&S costs we examined are from the Navy's VAMOSC data system. F-4J O&S costs are the average of O&S cost experience for FY 1987 to FY 1989; F-14A O&S costs are the average for FY 1990 to FY 1994. The F-4J was nearing

the end of its useful life in this time period, and its reported O&S costs may have been influenced by its advancing age. The F-14A was a relatively new aircraft during the O&S cost period. Reliable O&S cost data collected in a consistent fashion for the same list of cost elements does not exist prior to FY 1987. Therefore, the examination of F-4 data at the same time in the life cycle as the F-14A cannot be done.

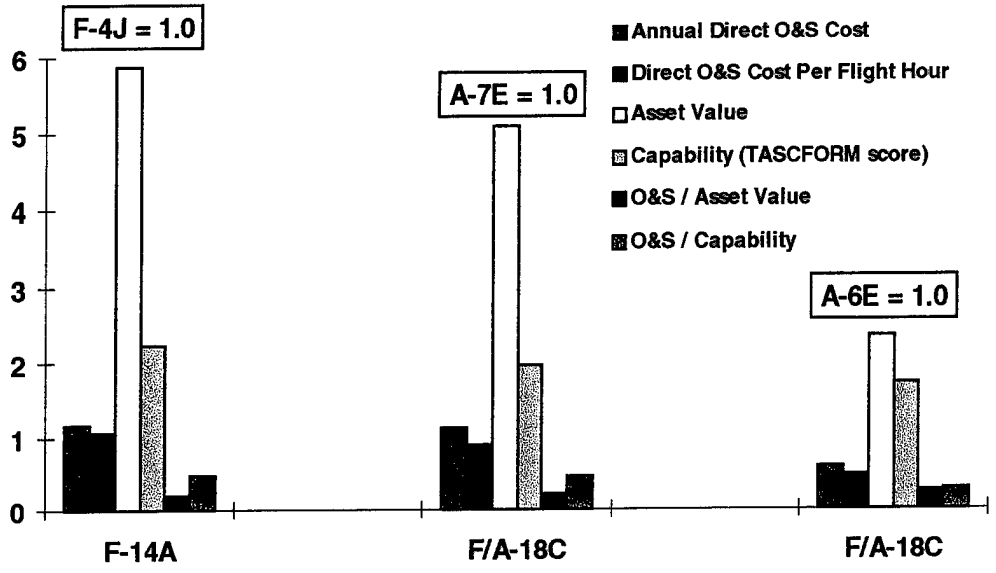

Figure III-16. Fighter and Attack Aircraft Comparisons

Organizational costs include costs for crew, organizational level personnel, fuel, supplies, training expendable stores, and depot-level repairable components. Annual organizational costs are 5 percent lower for the F-14A than for the F-4J, but the sum of intermediate plus depot maintenance is 8 percent higher for the F-14. Training support and recurring investment are considerably higher for the F-14A. For the F-14A, annual O&S costs are 16 percent higher, but annual flying hours were 18 percent higher. F-14A O&S costs per flight hour were 2 percent less than flight hour costs for the F-4J.

The asset value of the F-14A is 5.9 times the asset value of the F-4J. Annual O&S cost per dollar of asset value for the F-4J is 5 times the comparable value for the F-14A. The TASCFORM capability score is 124 percent higher for the F-14A. The ratio of O&S cost to the TASCFORM capability score of the F-14A is 53 percent lower than that of the the F-4J.

In summary, flight hour costs for the F-14A are almost equal while O&S costs for equal asset value or capability are far less than those of the F-4J. We conclude that

progress has been achieved in increased reliability and performance of 1995 era carrier-based fighter aircraft: F-14A O&S costs normalized for equal asset value or capability are significantly less in the 1990s compared to 1970s era F-4J aircraft.

3. A-6 and A-7 vs. F/A-18

Comparative operating and support cost and aircraft characteristic data are summarized in Tables III-13 and III-14 for the A-6E, A-7E, F/A-18A, and F/A-18C aircraft. Figure III-16 graphically summarizes the comparison of the A-7E and A-6E to the F/A-18C in several categories. Each vertical bar shown is the F/A-18C value relative to the A-7E (i.e., A-7E = 1.0) or A-6E (i.e., A-6E = 1.0).

The A-6 and A-7 aircraft were the primary attack mission aircraft of the FY 1975 and FY 1985 time periods. Both of these aircraft are subsonic with maximum speed around Mach .8 (at sea level). Both aircraft are being replaced by the F/A-18, a Mach 1.7+ supersonic aircraft with capabilities in both the attack and fighter missions.

The comparative O&S costs we examined are from the Navy's VAMOSC data system. A-6E and A-7E O&S costs are the average of O&S cost experience for FY 1987 to FY 1991; F/A-18 O&S costs are the average for FY 1990 to FY 1994. The A-6E and A-7E were nearing the end of their useful life in this time period, and reported O&S costs may have been influenced by their advancing age. The F/A-18A and F/-18C were relatively new aircraft during the O&S cost period. Reliable O&S cost data collected in a consistent fashion for the same list of cost elements does not exist before FY 1987.

Annual O&S costs for the F/A-18C are more than 40 percent lower than O&S costs for the A-6. F/A-18C annual O&S costs are 7 percent higher than comparable costs for the A-7E. Annual O&S costs for the F/A-18C model are 11 percent higher. On a per flight hour basis, the F/A-18A is 5 percent higher and the F/A-18C is 11 percent lower than flight hour costs for the A-7E. Fuel costs per flight hour are about $1,006 for the F/A-18A, $939 for the F/A-18C, $1,462 for the A-6E, and $514 for the A-7E. The installed thrust on the supersonic F/A-18 is about twice that of the A-6 and A-7.

Based on data in tables III-13 and III-14, the asset value of the F/A-18 is 134 percent higher than the asset value of the A-6E and 408 percent higher than the asset value of the A-7E. Annual O&S cost per dollar of asset value for the A-6 is more than 4 times the comparable value for the F/A-18, and the O&S per dollar of asset value for the A-7 is 4.6 times the F/A-18 value. The respective TASCFORM capability scores for the

F/A-18A or F/A-18C models are 68 or 73 percent higher than comparable values for the A-6E and are 90 or 95 percent higher than comparable values for the A-7E.

For all fighter/attack aircraft, the TASCFORM score is the average of scores for the attack (air-to-ground) and air-to-air missions. This approach was taken to acknowledge the dual-role capabilities of the F/A-18 aircraft in the scoring. The respective ratios of O&S cost to the TASCFORM capability score for the F/A-18A or F/A-18C are 67 or 73 percent lower than that of the A-6E. The respective F/A-18A or F/A-18C O&S cost-to-capability ratio are 44 or 55 percent lower than that of the A-7E.

In summary,

- F/A-18A/C flight hour costs are lower than those of the A-6E;
- F/A-18A flight hour costs are slightly higher than those of the A-7E; and
- F/A-18C flight hour costs are less than those of the A-7E.

O&S costs for equal asset value or capability are far less for the F/A-18 than for either the A-6 or A-7. We conclude that progress has been achieved in increased reliability and performance of the FY 1995 technology fighter or attack aircraft and that O&S costs normalized for equal asset value or capability are significantly less in FY 1995 technology F/A-18A/C than the FY 1975 technology A-6E or A-7E aircraft.

IV. DEPARTMENT OF THE AIR FORCE

A. DEPARTMENTAL OVERVIEW

The Air Force experienced a 13-percent decrease in O&S costs between FY 1975 and FY 1995. O&M costs rose by 9 percent over that same period. The Air Force reduced military personnel costs substantially, which more than offset the O&M increase. In the mission categories we studied, O&M costs changed as force levels changed, albeit by a smaller percentage. Figure IV-1 illustrates the relationships found between force and O&M changes.[1]

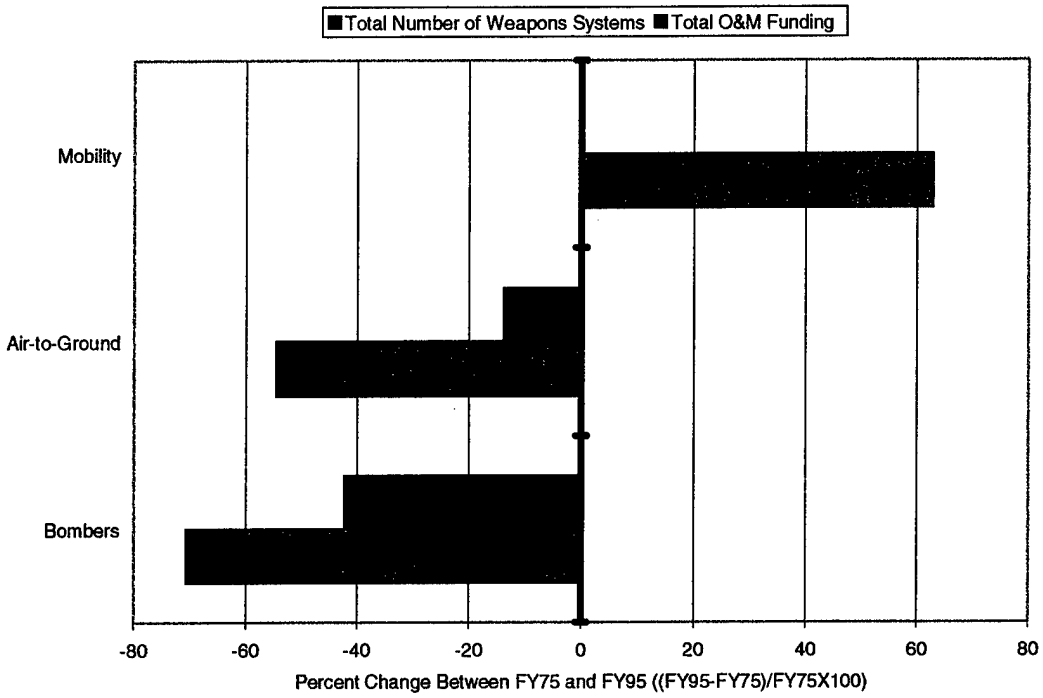

Figure IV-1. Percent Change in Forces Compared to Percent Change in O&M

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1 Mobility costs exclude O&S costs for strategic airlift. Although the cost of tactical airlift and certain support costs are available in the FYDP, the cost of strategic airlift is handled differently. Strategic airlift is financed through the Defense Business Operations Fund (DBOF) and all of its costs are therefore submerged within the budgets of its customers.

The parallelism of the changes shown for each Air Force mission and its O&M funding are what we expected to find in categories with force changes. We studied the three categories of Air Force forces shown in Figure IV-1 in an effort to understand why operating costs have not changed proportionately with changes in forces. We found that between FY 1975 and FY 1995:

- **Bombers** were cut 71 percent and total O&M decreased 42 percent. O&M per bomber increased 97 percent: flying hours per bomber decreased 4 percent.
- **Air-to-Ground** forces were reduced 55 percent and total O&M dropped 14 percent. O&M per aircraft increased 79 percent; flying hours per aircraft increased 14 percent.
- **Mobility** forces were increased 63 percent; however, we do not have an estimate for the O&M cost of this mission. Flying hours per aircraft dropped 51 percent.

Table IV-1 provides more details about these findings.

Table IV-1. Percent Change in Selected Air Force Mission Categories Between FY 1975 and FY 1995

Data Elements	Bombers	Air-To-Ground	Mobility
Total Number of Weapons Systems	-71	-55	63
Total O&M Funding	-42	-14	—[a]
Total Military Personnel Pay	-55	-46	—[a]
Total O&S	-48	-30	-4
Total Flying Hours	-72	-48	-20
Total Asset Value	-25	-5	60
Total Capability Units	-56	-34	10
Average Age	62	45	248
Fly Hours Per Weapon system	-4	14	-51
O&M Per Weapon System ($M)	97	90	—[a]
O&S Per Weapon System ($M)	79	53	-41
O&S Per Flying Hour (K$)	86	35	—[a]
O&S Per $10K Asset Value ($)	-30	-27	—[a]
O&S Per Capability Unit ($H)	19	6	—[a]

[a] Mobility O&M cost not available.

Figure IV-2 shows O&M costs for selected aircraft within the mission areas we studied. We can see from Figure IV-2 that annual O&M costs for similar types of aircraft within each mission vary considerably. Of course much of the variation is associated with the F-111, B-2, and F-117. Each of these aircraft introduced new technologies that probably account for much of the increase in its O&M costs. Otherwise, O&M costs tend

to increase slowly in successive models within type, except where there has been a substantial mission change.

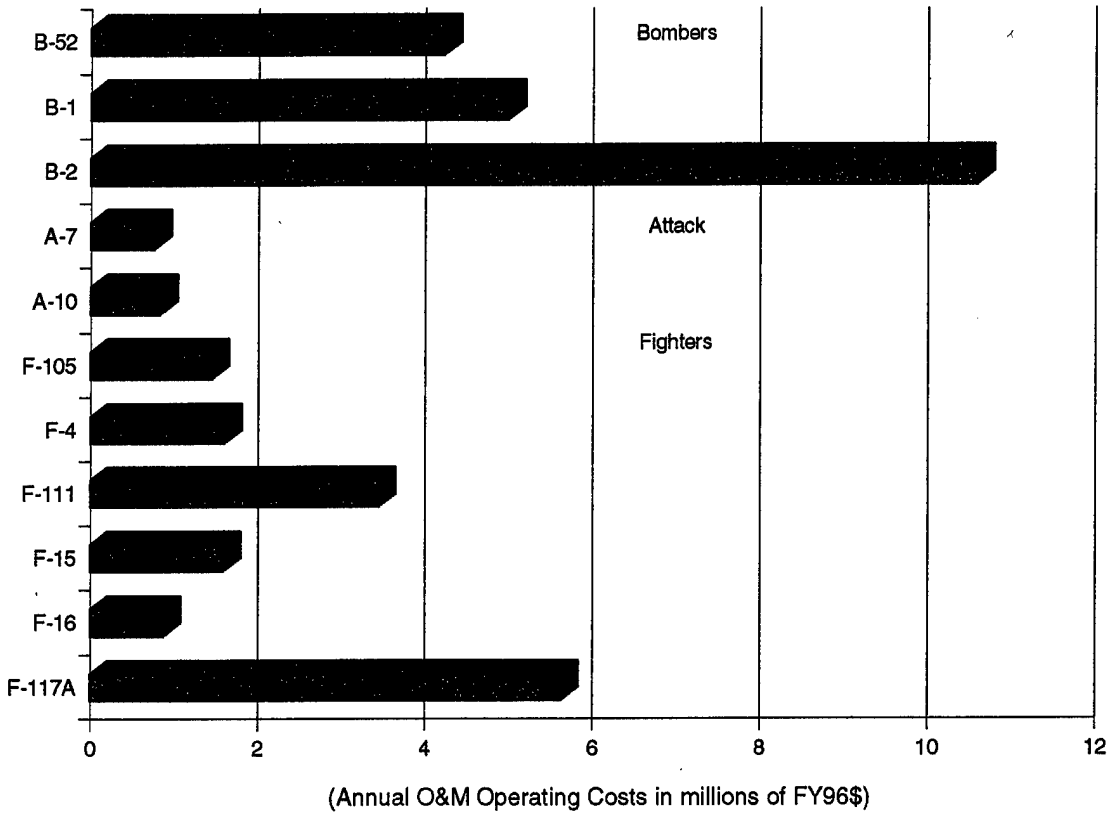

Figure IV-2. Annual O&M Operating Costs by Aircraft Type and Model

B. MISSION CATEGORY REVIEW

1. Analyses by Defense Mission Category (DMC)

For the Air Force's mission category review, we chose to study the bomber, air-to-ground, and mobility mission areas. Figure IV-3 shows the O&S trends in these three areas.

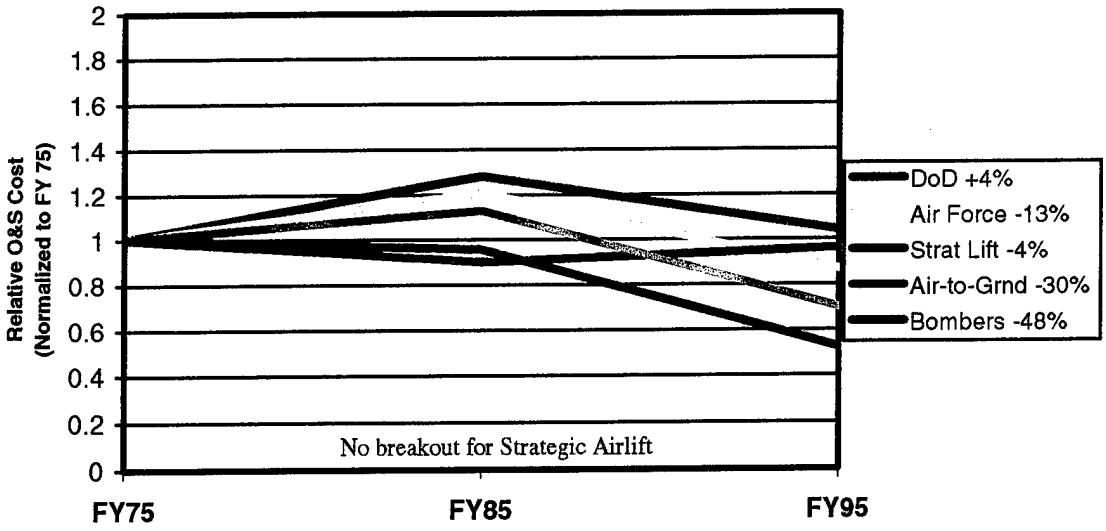

Figure IV-3. O&S Trends in Selected Air Force Missions

Notice that O&S costs for bomber and air-to-ground missions dropped more than those same costs for the total Air Force. The strategic airlift mission military pay costs decreased somewhat even thought there was a large increase in total aircraft between FY 1975 and FY 1995.[2] Figure IV-4 shows the changes in O&M for the selected missions.

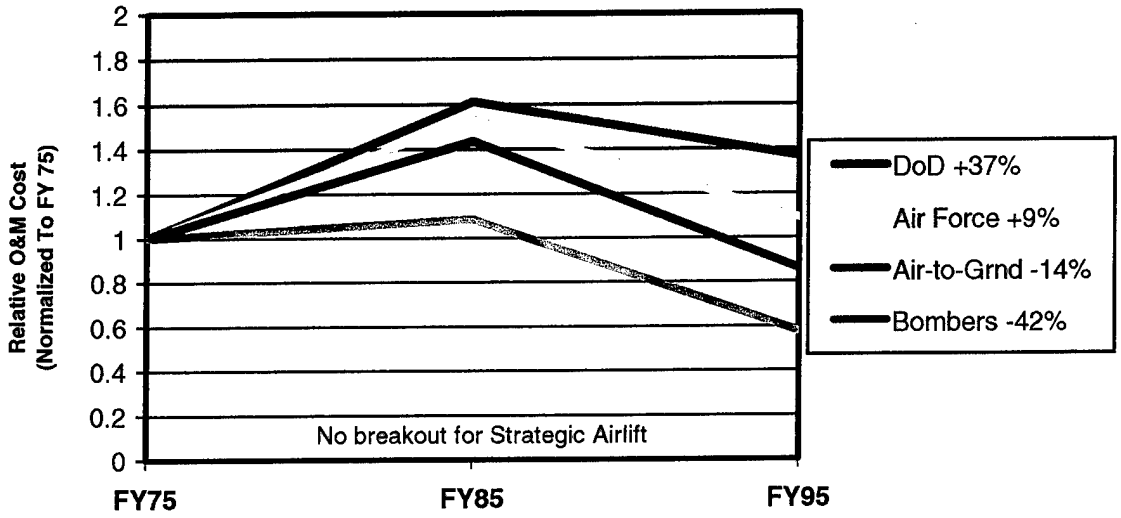

Figure IV-4. O&M Trends in Selected Air Force Missions

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2 O&M data for the airlift category are not available.

FY 1995 O&M cost for bombers and air-to-ground aircraft decreased by 42 and 14 percent, respectively, relative to FY 1975. Again, notice that the costs for these missions dropped more than total Air Force. Let's take a closer look at the underlying data in each area. We'll begin with the bombers.

2. Bombers

Table IV-2 data show that bombers and their flying hours were reduced by over 71 percent during the FY 1975-95 period, yet total O&S and O&M dropped only 48 and 42 percent, respectively. As a result, average O&S cost per bomber increased by over 79 percent, and average O&S cost per flying hour increased by 86 percent.

Figure IV-5 shows these data in chart form. The drop in total asset value is consistent with the large drop in the size of the force, which is offset somewhat by the acquisition cost of some new bombers. The drop in capability is also consistent with the large drop in the number of bombers.

Table IV-2. Bomber Mission Data (FY 1996$)

Data Elements	FY75	FY85	FY95
Aircraft	396	298	116
O&S ($M)	2,820	2,692	1,478
O&M ($M)	1,673	1,815	967
Military Personnel ($M)	1,146	877	512
Flying Hours	170,573	125,900	48,178
Asset Value ($M)	30,875	23,148	23,149
Capability Index[a]	10,341	8,404	4,545
Average Age	14.1	23.0	22.9
Flying Hours Per Aircraft	431	422	395
O&S Per Aircraft ($K)	7,121	9,032	12,743
O&S Per Flight Hour ($)	16,531	21,379	30,681
O&S Per $1K Asset Value ($)	9,133	11,628	6,385
O&S Per Capability Unit ($H)	2,727	3,203	3,253
Equipment Data			
B-52	330	241	66
FB-111	66	56	0
B-1	0	1	50
B-2[b]	0	0	6

[a] Uses TASCFORM capability scoring system. Does not include value or capability of carried weapons systems.

[b] B-2 not included in the analysis since units were not operational in FY 1995.

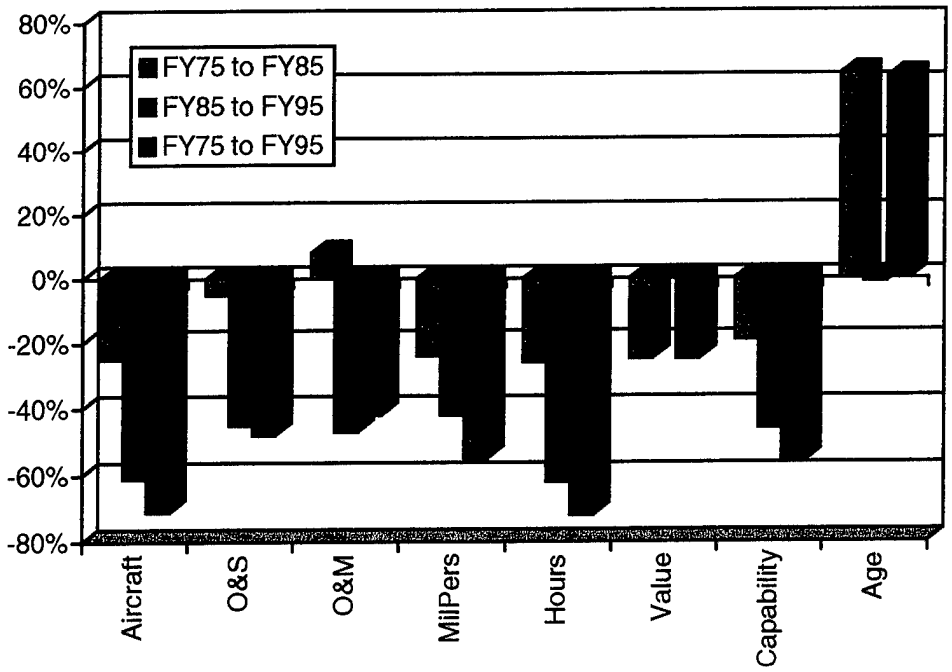

Figure IV-5. Bomber Mission
Total Resources and Performance Changes

Figure IV-6 shows the values for each useful analytic ratio for O&S costs. O&S cost per bomber and per flying hour have both increased while O&S cost per unit of asset value has decreased and O&S per unit of capability has increased.

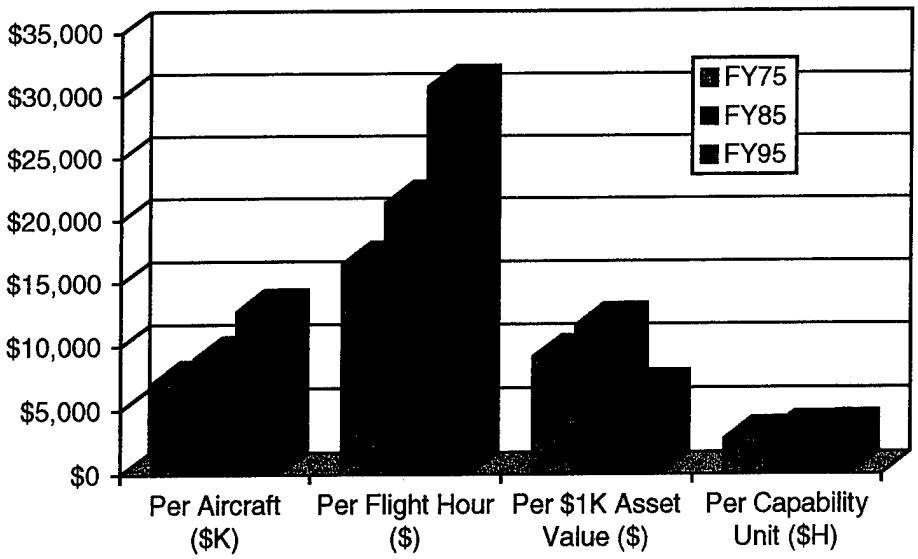

Figure IV-6. Bomber Mission O&S Cost Ratio Changes

How has modernization affected the weapons inventory of this mission area? Referring back to Table IV-2, we find that bomber aircraft modernization has been substantial during this period, specifically,

- B-52s decrease from 330 to 66,
- FB-111s drop from 66 to 0,
- B-1s increase from 0 to 50, and
- B-2s increase from 0 to 6.

How has modernization changed mission operating costs? The annual operating cost figures in Table IV-3 show that the more modern bombers require more O&M each year than the older versions.

Table IV-3. Bombers (FY 1995 $M)

Type and Model	O&M
B-2	10.6
B-1	4.9
FB-111	3.6
B-52	4.2

Table IV-2 shows that cost of bomber operations in the O&M appropriation has decreased substantially, but did it decrease in the appropriate amount? Logically, the cost of bomber operations should have:

- decreased by 71 percent due to the reduction in the number of bombers;
- decreased by approximately 4 percent more due to the reduction in the average flying hours per aircraft; and
- increased by about 15 percent due to the shift to a more expensive bomber mix (increased B-1s, decreased B-52s and FB-111s).

The overall O&M change reflected in the FYDP is a drop of about 42 percent. Using the factors from Table IV-3, we can calculate the drop in direct O&M costs for these bombers between FY 1975 and FY 1995 at about 68 percent. It appears that some of the O&M savings were offset by increases in other areas in the bomber mission area.

3. Air-To-Ground Forces

Table IV-4 contains all of the basic data we collected for this mission area.

Table IV-4. Air-to-Ground Mission Data

Data Element	FY75	FY85	FY95
Aircraft	1,572	1,266	714
O&S ($M)	3,238	3,650	2,256
O&M ($M)	1,558	2,234	1,343
Military Personnel ($M)	1,679	1,416	913
Flying Hours	503,475	173,600	260,232
Asset Value ($M)	25,134	28,184	23,842
Capability Index[a]	23,257	14,199	15,361
Average Age	6.5	8.1	9.4
O&S Per Aircraft ($K)	2,060	2,883	3,160
O&S Per Flight Hour ($)	6,431	21,023	8,671
O&S Per $10K Asset Value ($)	12,881	12,949	9,464
O&S Per Capability Unit ($H)	1,392	2,570	1,469
Equipment Data			
A-7	216	0	0
A-10	0	300	72
F-4	1,044	312	24
F-15E	0	0	138
F-117A	0	0	36
F-105	36	0	0
F-111	276	198	54
F-16	0	456	390

[a] TASCFORM Scoring.

The numbers of aircraft in the air-to-ground mission were reduced by 55 percent between FY 1975 and FY 1995, and their total flying hours were decreased by 48 percent. Total O&S cost dropped by 30 percent, while military personnel costs dropped by 46 percent and O&M decreased by only 14 percent. Because the total O&S cost dropped by a smaller percentage than the force structure, average O&S cost per aircraft increased by 53 percent and average O&S cost per flying hour increased by 35 percent.

As Figure IV-7 shows, changes to total O&S, the number of aircraft, and total flying hours are straightforward. Total asset value decreased slightly, and capability dropped by over 30 percent.

Figure IV-8 shows the values for each of our standard ratios. O&S cost per aircraft increased by 53 percent and O&S per flying hour increased by 35 percent. O&S cost per unit of asset value dropped by 27 percent and O&S per unit of capability grew by 6 percent.

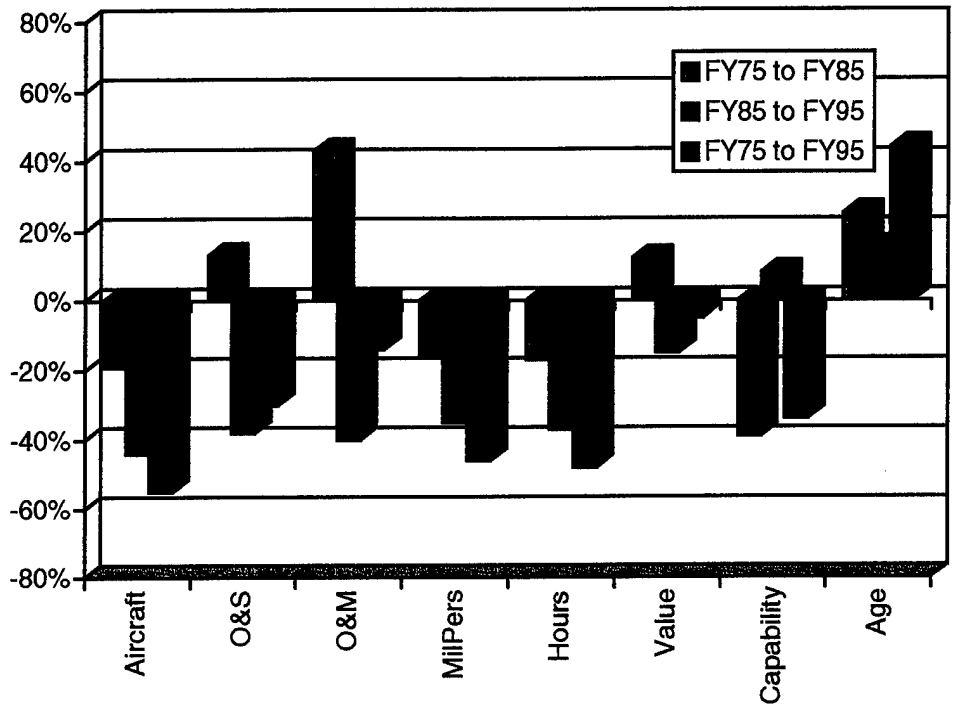

Figure IV-7. Air-to-Ground Mission Total Resources and Performance Changes

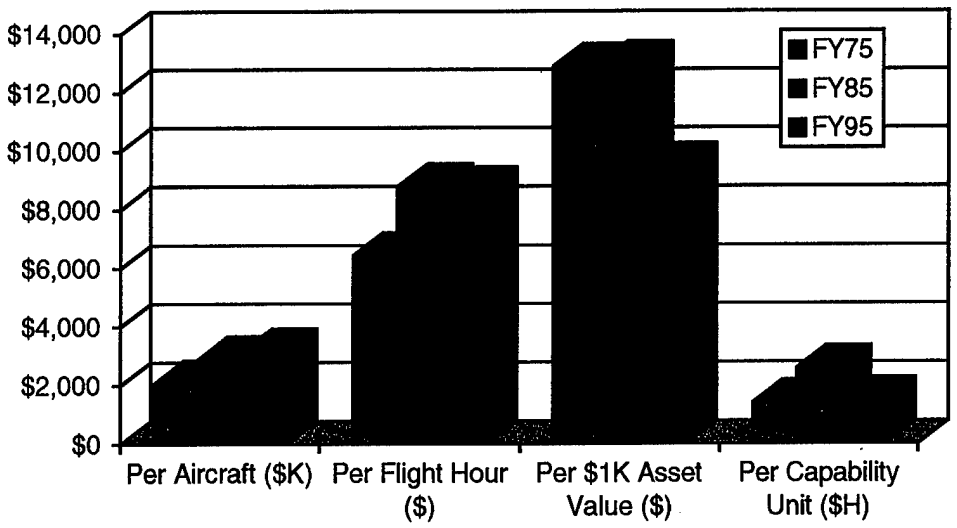

Figure IV-8. Air-to-Ground Mission O&S Cost Ratio Changes

Air-to-ground aircraft inventories have been substantially modernized. Table IV-5 focuses on air-to-ground aircraft inventories from Table IV-4. The A-7s and F-105s were completely replaced during the FY 1975-95 period. The A-10s, F-15s, F-117s, and F-16s were introduced during the period and the F-4s and F-111s were greatly reduced.

Table IV-5. Air-to-Ground Aircraft Force Modernization

Type and Class	FY75	FY95
A-7	216	0
A-10	0	72
F-4	1,044	24
F-15E	0	138
F-117a	0	36
F-105	36	0
F-111	276	54
F-16	0	390

How has modernization changed mission operating costs? The annual operating cost figures in Table IV-6 show that the operating costs of most newer aircraft are not markedly different from older aircraft of the same type. This is especially true if the F-117 and the F-111 are considered as aircraft that were unusually expensive because they introduced substantial amounts of new technology.

Table IV-6. Air-to-Ground Aircraft Annual O&M Operating Costs (FY 1995 $M)

Type and Model	O&M
F-117A	5.6
F-16	0.9
F-15	1.6
F-111	3.4
F-4	1.6
F-105	1.4
A-10	0.8
A-7	0.7

Adding A-10s, F-15s, F-117s, and F-16s should have added about $831 million in annual O&M operating costs. Retiring A-7s and F-105s and scaling back the F-4s and F-111s should have saved a little over $2,588 million per year in O&M operating costs. This nets out to about $1,757 million in annual savings. Table IV-4, however, shows air-to-ground forces O&M costs have decreased by only $215 million, or, 14 percent.

Very little of the savings have been offset by increases in the average flying hours per aircraft.

- In FY 1975, a total of 503,475 flying hours was allocated among 1,572 aircraft to produce an average of 320 flying hours per aircraft.
- In FY 1995, a total of 260,232 flying hours was allocated among 714 aircraft to produce an average of 364 flying hours per aircraft, an increase of approximately 14 percent.

It appears that O&M increases in other air-to-ground programs have preempted a substantial amount of the potential savings expected from aircraft retirements.

4. Mobility

Table IV-7 contains all of the basic data we collected for this mission area. It shows that between FY 1975 and FY 1995:

- The total number of aircraft increased 63 percent while flying hours dropped 20 percent.
- There was a 4-percent decline in total O&S. O&M data are not available for this mission area so the O&S is really only the military personnel costs.
- Asset value increased by 60 percent and mission capability increased by only 10 percent.

Table IV-7. Mobility Mission Data (FY 1996$)

Data Elements	FY75	FY85	FY95
Aircraft	304	296	459
O&S (estimated)	2,583	2,319	2,480
O&M	—	—	—
Military Personnel	—	—	—
Flying Hours	353,137	306,643	282,200
Asset Value ($M)	26,926	25,373	43,001
Capability Index[a]	9.8	9.2	10.8
Average Age	7.7	18.0	26.8
Flying Hours Per Aircraft	1,162	1,036	615
O&S Per Aircraft ($K)	8,495	7,833	5,403
O&S Per Flight Hour ($)	7,313	7,561	8,788
O&S Per $100K Asset Value	9,592	9,138	5,767
O&S Per K ton-miles ($H)[a]	2,644	2,528	2,302
Equipment Data			
C-17	0	0	17
C-5	70	62	64
C-141	234	234	143
KC-135	0	0	187
KC-10A	0	0	48

[a] Million ton-miles per hour.

Figure IV-9 shows these data in chart form.

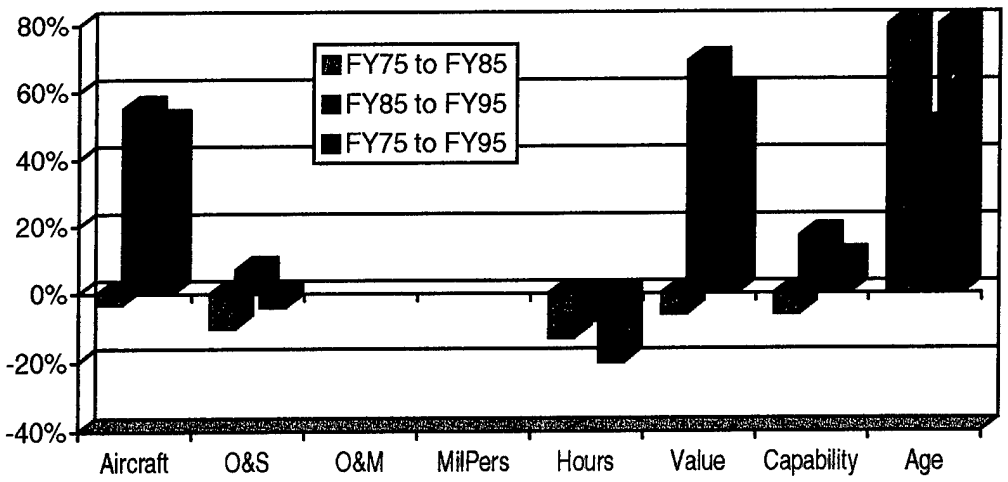

Figure IV-9. Mobility Mission Total Resource and Performance Changes

Looking next at the "per unit" section of the Table IV-7, notice that between FY 1975 and FY 1995, the O&S cost:

- Per aircraft decreased by 41 percent,
- Per flying hour increased by 20 percent,
- Per $10K of asset value dropped by 40 percent, and
- Per unit of capability dropped by 13 percent.

Again, Figure IV-10 shows these data in chart form.

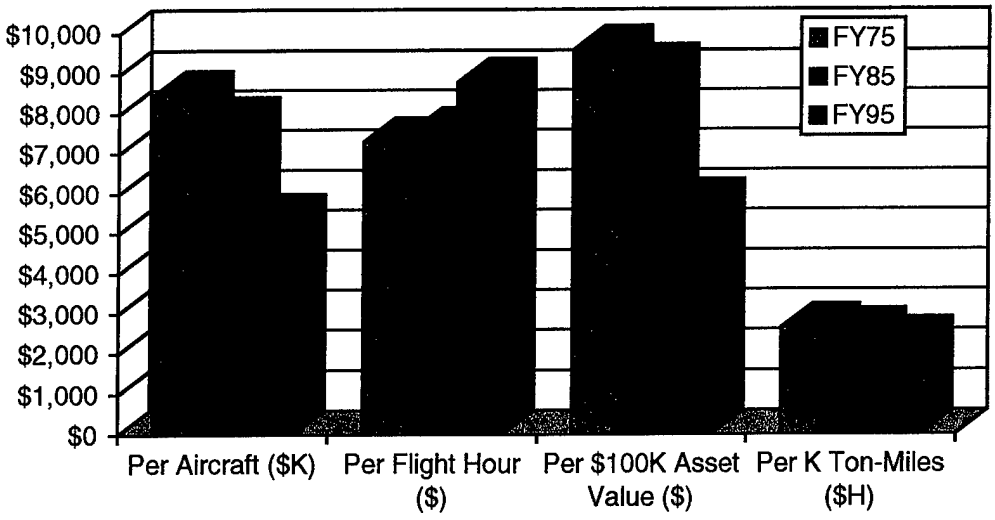

Figure IV-10. Mobility Mission O&S Cost Ratio Changes

In summary, the Air Force's experience in this mission area is typical, in some respects, of those missions in which substantial modernization has taken place during the 20-year period:

- O&S cost per flight hour is up,
- O&S cost per unit of asset value is down, and
- O&S cost per unit of capability is down.

However, the mobility mission area differs with respect to one of our measures:

- O&S cost per aircraft is down, rather than up.

Flying hours per aircraft decreased 47 percent for the mobility mission, and as a result, O&S cost per aircraft decreased about 36 percent.

C. CASE STUDIES

1. Bomber Aircraft: B-52H vs. B-1B

Comparative O&S cost and bomber aircraft characteristic data are summarized in Table IV-8 for the B-52H and B-1B aircraft.

O&S cost per flight hour for the B-1B are 21 percent higher, asset value is 440 percent higher, and capability is 73 percent higher than those values for the B-52H. The faster growth in capability and asset value than in O&S cost results in lower O&S cost per unit of capability or asset value for the B-1B, compared to the B-52H.

2. Fighter Aircraft: F-4E vs. F-16C

Comparative O&S cost and fighter aircraft characteristic data are summarized in Table IV-9 for the F-4E and F-16C fighter aircraft.

From FY 1990 through FY 1994 the F-16C flew more than 1,000,000 flight hours while the older F-4Es flew 61,000 flight hours. O&S cost per aircraft for the F-16C were 27 percent lower than O&S costs for the F-4E. On a cost per flight hour basis, F-16C O&S costs are 30 percent lower. The F-16C flew an average of 344 flight hours per year while the F-4E flew an average of 327 flight hours per year on from FY 1990 to FY 1994.

The F-16C is somewhat lighter and smaller than the F-4E. Both fighters are supersonic in the Mach 2+ class. The F-16C is powered by a single turbofan while the F-4E has two turbojet engines with more than twice the total thrust per aircraft of the F-16C. Fuel consumption costs and depot maintenance costs for the F-4E are also more than twice

comparable F-16C costs. The F-16C is configured to carry a broad range of modern weapons that cannot be carried on the F-4E without significant aircraft modification.

Table IV-8. O&S Costs and Characteristics for Air Force Bombers (Cost Data in Thousands of Constant FY 1996 Dollars)

Cost Elements	B-52H	B-1B
Mission Personnel	3,240	2,508
Unit Level Consumption		
Aviation Fuel	1,130	963
Other Unit Level	1,296	1,392
Depot Maintenance	1,593	606
Contractor Support	85	1,459
Sustaining Support	723	883
Indirect Support	3,244	2,490
Total Annual O&S Per PAA	11,312	10,302
Flight Hours Per Year	429	320
O&S Cost Per Flight Hour	26.809	32.404
Cost Per Flight Hour Ratio	1.00	1.21
Characteristics		
Max. T. O. Weight (pounds)	488,000	477,000
Dimensions (feet)		
Length	161 ft	147 ft
Wingspan	185 ft	137 ft
Max Speed at High Altitude	Mach 0.9	Mach 1.25
Low Altitude Penetration Speed	405 - 420 mph	600 mph
Max Unrefueled Range	10,000 mi	7,455 mi
Power Plant	817,000lb Turbofans	431,000lb Turbofans
Crew	6	4
Typical Squadron Size	875	731
Armament		
AGMs	ALCMs, SRAM	ALCMs, SRAM
Bombs	Conventional Nuclear	Conventional Nuclear
Asset Value	51,600	278,500
TASCFORM Score	29.839	51.503

Source: O&S cost data are from the Air Force VAMOSC database. Costs are the average of 5 years of operations including the years from FY 1990 to FY 1994. Flight hours per year are the 5 year average of the actual flight hour program.

Table IV-9. O&S Costs and Characteristics for Air Force Fighter Aircraft (Cost Data in Thousands of Constant FY 1996 Dollars)

Cost Element	F-4E	F-16C
Mission Personnel	1,635	1,353
Unit Level Consumption		
Aviation Fuel	450	220
Other Unit Level	456	382
Depot Maintenance	1,062	349
Contractor Support	14	101
Sustaining Support	268	126
Indirect Support	1,872	1,690
Total Annual O&S Per PAA	5,756	4,221
Flight Hours Per Year	327	344
O&S Cost Per Flight Hour	17.542	12.261
Cost Per Flight Hour Ratio	1.00	0.70
Characteristics		
Max. T. O. Weight (pounds)	54,600	42,300
Dimensions (feet)		
Length	58	49
Wingspan	38	31
Max Speed At High Altitude	Mach 2+	Mach 2+
Combat Radius (Interceptor)	900 miles	710
Power Plant	2 Turbojets	1 Turbofan
Total Thrust	34,000	29,600
Crew	2	1 (2)
Armament		
Air-To-Air	Sparrow Sidewinder	Sparrow, Sidewinder AMRAAM, Sky Flash
Air-To-Surface	Conventional, Nuclear Bullpup ASM, Rockets Bombs	Conventional, Nuclear Maverick, HARM Shrike, HARPOON Bombs
Asset Value ($Ks)	$10,400	$16,200
TASCFORM Score	10.926	16.290

Source: O&S cost data are from the Air Force VAMOSC database. Costs are the average of 5 years of operation, including the years from FY 1990 to FY 1994. Flight hours per year are the 5 year average of the actual flight hour program.

O&S cost per flight hour for the F-16C are 30 percent lower while asset value is 56 percent higher and capability is 49 percent higher than that of the F-4E. The growth in capability and asset value combined with the reduction in O&S cost results in much lower O&S cost per unit of capability or asset value for the F-16C compared to the F-4E. That F16-C O&S cost per aircraft or per flight hour are lower and asset value and capability are higher is a very positive result from O&S cost reduction efforts.

3. Transport Aircraft: C-5A vs. C-5B

Comparative O&S cost and transport aircraft characteristic data are summarized in Table IV-10 for the C-5A and C-5B transport aircraft.

Table IV-10. O&S Costs and Characteristics for Air Force Transport Aircraft (Cost Data in Thousands of Constant FY 1996 Dollars)

Cost Elements	C-5A	C-5B
Consumable Supplies		
General Support Division	231	530
Special Support Division	123	237
Depot Maintenance	1,104	682
Depot Level Reparables	1,034	1,752
Fuel	1,376	2,699
Annual Direct O&S Cost ($K)	3,867	5,900
Flight Hours Per Year	497	1,011
O&S Cost Per Flight Hour	7.78	5.84
O&S Cost Per Flight Hour Ratio	1	0.75
Characteristics		
Max Take-off Weight	769,000	837,000
Max Zero Fuel Weight	558,904	635,000
Max Wing Loading	124 lbs./sq. ft.	135.5 lbs./sq. ft.
Max Speed	571 mph	571 mph
Powerplant	4 TF39-GE-1	4 TF39-GE-1C
Thrust Per Aircraft	164,000	172,000
Crew	5	5
Asset Value	124,500	184,200
Capability (ton-miles per hour)	74,516	74,516

Source: O&S costs were not available in VAMOSC for C-5 aircraft. Program factors from AFI 65-03 are used here except for flight hours per year, which is the actual average flight hours per year for FY 1990 to FY 1994. This set of cost elements is limited by the data available in AFI65-03.

These transport aircraft are not currently included in VAMOSC reporting, but they will be included in future VAMOSC reports. Air Force program factors reported in AFI 65-03 are based on actual cost experience applied to programmed activity levels to estimate future program funding requirements. Table A3-1 in AFI 65-03 has per flight hour cost factors for the list of cost elements included in Table IV-10. Actual flight hour experience for FY 1990 to FY 1994 for the C-5A and C-5B are shown in Table IV-10. The costs shown in Table IV-10 are the flight hour cost factors from AFI 65-03 applied to actual 5-year average flight hours per transport aircraft.

The C-5B model is similar to the C-5A, but it incorporates an advanced version (-1C) of the same turbofan with 5 percent more thrust. Take-off and empty weight are also higher for the B model. The C-5B also has a number of other improvements that were incorporated into the A model over the years through the product improvement and modification process. The asset value of the C-5B is 48 percent higher than the original C-5A. The capabilities of both models are the same. O&S cost per flight hour for the list of cost elements considered are 25 percent less for the B model (based on flight hour costs in AFI 65-03). Thus, O&S per unit of capability or asset value for the C-5B is lower than that of the C-5A.

4. Tanker Aircraft: KC-135A vs. KC-135R

Comparative O&S cost and transport aircraft characteristic data are summarized in Table IV-11 for the KC-135A and KC-135R tanker aircraft. From FY 1990 through FY 1994 the KC-135R flew 511,000 flight hours. The older KC-135A flew 180,000 flight hours from FY 1990 to FY 1992 and was phased out of the inventory by FY 1994.

The KC-135R is an example of a program with multiple objectives, including O&S cost reduction, performance enhancement, and life extension. Compared to the KC-135A, the R model has 4 turbofan engines with 60 percent more thrust than the turbojets on the A model. With structural improvements, the KC-135R carries considerably more fuel for the refueling mission and needs a 2,500 feet shorter runway for operations. These performance enhancements were achieved at lower fuel, depot maintenance, and other operating costs due largely to the efficiency of the new turbofan engines.

O&S cost per flight hour for the KC-135R is 30 percent lower than O&S cost per flight hour for the KC-135A. Asset value is 200 percent higher and capability is about 100 percent greater in the KC-135R. O&S cost per unit of capability or asset value declined by more than 50 percent with the introduction of the KC-135R. This program has achieved significant improvements in both O&S cost reduction and capability improvement.

Table IV-11. O&S Costs and Characteristics for Air Force Tanker Aircraft (Cost Data in Thousands of Constant FY 1996 Dollars)

Cost Element	KC-135A	KC-135R
Mission Personnel	1,982	1,574
Unit Level Consumption		
Aviation Fuel	683	535
Other Unit Level	211	388
Depot Maintenance	1,024	451
Contractor Support	18	24
Sustaining Support	281	98
Indirect Support	2,189	1,767
Total Annual O&S Per PAA	5,756	4,837
Flight Hours Per Year	437	462
O&S Cost Per Flight Hour	15	10.509
Cost Per Flight Hour Ratio	1	0.7
Characteristics		
Max Take-off Weight	301,600	322,500
Max Fuel Load	189,702	203,288
Powerplant	4 J57-P-59W	4 CFM56
Thrust Per Aircraft	55,000	88,000
Crew	4	4
Asset Value	17,300	52,200
Capability (Fuel Offloaded)		
at 1,500 nmi		65 percent more
at 2,500 nmi		150 percent more
Average gross weight take-off run		2,500 feet shorter

Source: O&S costs are from the USAF VAMOSC data system. KC135R data are average costs from FY1990 to FY 1994. KC135A data are average costs from FY 1990 to FY 1992 because they were phased out of active inventory in FY 1993 and FY 1994.

V. O&S COST REDUCTION THROUGH EQUIPMENT MODIFICATION

We made several inquiries to determine if there are historical examples from the 1975 to 1990 time period where significant reduction in O&S costs were achieved by an equipment modification or engineering change proposal (ECP). We wanted to find examples where verifiable "before and after" O&S cost data would show the exact impact of the modification.

We interviewed representatives from the Army Tank and Automotive Command, the Apache Helicopter Program Manager's staff, Navy's Headquarters staff and Smart Ship and SHARP program representatives, and the Air Force's F-15 program and Air Logistics Center staffs. Based on these interviews we concluded that there undoubtedly were cases where component improvements resulted in lower O&S costs, but the effects are probably not visible in aggregated O&S cost accounting data. Changes in inventory, OPTEMPO, other non-cost-reducing modifications, and other utilization factors that routinely occur from period to period would make it difficult to isolate the cost-reducing effects of an individual component modification, and prohibitively expensive and time-consuming to analyze all programs for such changes.

Furthermore, past equipment modifications have been motivated by the need to meet safety requirements, to correct reliability problems that caused an unacceptably low readiness rate, or to achieve a higher level of system performance. Past programs have not been motivated by a desire to reduce O&S cost. As a byproduct of an equipment modification that resulted in a reduced failure rate, the O&S cost may have been reduced, but this was of second-order importance, and the modifications generally did not have a visible impact on aggregated O&S cost totals.

As a result of Dr. Kaminski's initiatives, for the first time the Services have initiated programs that have O&S cost reduction as the primary goal. Teams have been created to review all aspects of equipment operation and to develop proposals for reducing O&S cost. The Navy's Smart Ship program is a good example. An AEGIS ship has been designated as a test platform for 72 changes in both equipment and manning. Some of the ideas for these changes were obtained from commercial activities in response

to an open request from the Navy over the Internet. Impacts of these changes on cost and ship operations are being evaluated. However, O&S cost reductions will not be clearly visible in O&S cost accounting reports for around 3 to 5 years after they are approved for full implementation.

APPENDIX A

NORMALIZING THE FYDP FOR FUNDING POLICY CHANGES

THE NEED FOR ADJUSTMENTS

In fiscal year (FY) 1981, the Department of Defense (DoD) began requiring operational commanders and their supporting field activities to budget directly for big expenses that had been managed centrally at higher levels. As a result, large sums of money shifted from DoD's overhead accounts to the accounts of users, or "customers." As they were phased-in over the last 15 years, these new policies significantly redefined the cost content of every accounting category they touched. Today these changes affect a majority of the FYDP program elements, many congressional appropriations, and the size of service and defense agency budgets.

Please note that our estimates of accounting policy adjustments were often derived from documentation of Program Budget Decisions (PBDs) and Defense Management Review Decisions (DMRDs). When applying a factor we derived from a PBD or DMRD, we necessarily assumed that the derived factor is constant across the time span of our database. While we believe this approximation makes the correct order of magnitude change, the reader should be aware that this procedure can introduce errors in the details. We also wish to emphasize that our efforts address only accounting policy changes. Program content and policy changes, such as, contracting manpower, privatization, and outsourcing, are not addressed.

EXAMPLES OF THE IMPACT OF BUDGET POLICY CHANGES

Changes in budgeting policies can have a profound effect on a FYDP-based analysis. For example, Figure A-1 shows that $175 billion has shifted from infrastructure overhead accounts to core combat missions due to such changes. A linear trend line added to Figure A-1 would look very different if the changes data were excluded. This particular data shift is important in determining whether Operations and Maintenance (O&M) spending on combat forces has gone up, stayed the same, or declined since the early 1980s.

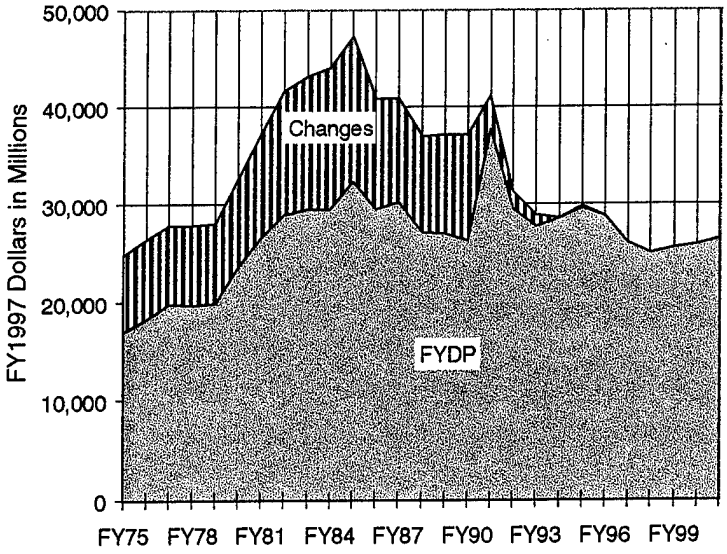

Figure A-1. Core Combat Mission O&M With and Without Funding Policy Changes

As another example, let's say that you want to use FYDP data to assess changes in the operating cost of combat units over time. But before you begin, someone shows you the following list of changes to the accounting policy for spare parts:

- FY 1962–1980: spare parts repair costs were centrally managed in FYDP Program 7;
- FY 1981: Navy ship depot-level reparables (DLRs) were moved into the stock fund and their funding was shifted from Program 5 and 7 centralized depot maintenance accounts to the budgets of customers who use spare parts;
- FY 1985: Navy aviation DLRs went to the stock fund; and
- FY 1991: Army and Air Force DLRs went to the stock fund.

Later you discover that, over this same period, funding for replacement spares shifted from procurement to the stock fund. As a result, the money to buy new spares currently appears in DoD budgets as O&M expenses in the customer's program element. We estimate that nearly $100 billion (in FY 1997 constant dollars) in spares funding shifted from Infrastructure overhead accounts to operating unit budget accounts between FY 1975 and FY 1995. Not recognizing this large shift of resources from the overhead accounts to operating units could bias the results of your study.

If you conclude from the above, as we did, that you must adjust the FYDP for funding policy changes, you are probably wondering what to do now. Here is our advice:

- ***Be careful when using our adjustment data for micro-analyses.*** In some cases the data adjustments are incomplete and may be misleading, particularly at the level of individual program elements. Be aware of this when using the adjusted data for micro-analysis. Still, we believe the adjusted FYDP is the most consistent comprehensive compilation of defense spending available.
- ***Use our adjustment data more confidently for macro-analyses.*** If a fair approximation of the real adjustments is suitable for your analysis, as they are for many FYDP-based macro-analyses, you can use the adjustments database we have developed directly with your current FYDP data files.

SUMMARY OF FUNDING POLICY CHANGES

Table A-1 highlights the nature of the accounting changes we have studied so far. The general impact of the changes listed in Table A-1 was to shift funds:

- *Among the congressional appropriations.* This results in a net increase in Operating and Support funding and a net decrease in Investment funding.
- *From centrally managed infrastructure accounts (mostly Program 7) to core mission forces customer accounts (mostly Programs 1 through 5).*[1] This produces a dramatic increase in core mission costs from FY 1981 forward.
- *Between military department and defense agency budgets.* This produces a net increase to defense agency funding, but large sums shift in each direction.

Chapter II describes each funding policy change, explains the adjustment methodology, and summarizes the data.

How much do these funding policy changes affect the FYDP? Table A-2 shows their effects in three ways:

- impact on the total O&M appropriation,
- shifts between customer accounts and centrally funded overhead accounts, and
- shifts between service and defense agency budgets.

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1 The term "infrastructure," as used in this paper, refers in general to the FYDP program elements (PEs) covered in the Defense-Wide Support Missions section of the Defense Mission Categories (DMCs). "Core missions" is a category of PEs that has been used in studies of how well DoD is maintaining the readiness of combat mission forces. Simply stated, core missions are those elements of force structure found in FYDP Programs 1 through 5 and 11 except supporting programs, such as base operating support and headquarters.

Table A-1. Funding Policy Changes Addressed to Date

Policy Change	Description of Change
Supply	Distribution depots and inventory control point costs move from a centrally managed account funded by direct appropriations to a stock fund that recovers costs by charging its customers.
Contract Management	Most contract administration functions in the military departments move to the Defense Contract Management Command (DCMC).
Commissary Operations	Service commissary O&M funds move to the Defense Business Operations Funds (DBOF)[a] area supporting the Defense Commissary Agency (DeCA).
Subsistence-in-Kind	Subsistence-in-kind funds move to military personnel funding found in most program elements from O&M funds located in a single overhead program element in each service.
Spares	Spares funding, except for initial spares and war reserves, moves to the O&M budgets of spares customers, (i.e., funds for buying new spares move to O&M from the customer's procurement budget and funds for repairing spares move to the customer's O&M account from a centralized depot maintenance O&M budget).
Equipment Modification Installation	Funds for installing equipment modifications move from a centrally managed O&M budget to the customers' procurement accounts.
Air Force Depot Maintenance	Centrally managed depot maintenance O&M funds move to the customers' O&M budgets. The other services continue to manage depot maintenance funding centrally except for Navy ships.
First-Destination Transportation	First-destination transportation funding moves from O&M to procurement in the same centrally managed program elements.
Medical Programs	Selected service and agency medical O&M funding moves to a new medical O&M appropriation in the Office of the Secretary of Defense (OSD) Defense Health Program.
Special Operations Forces (SOF)	SOF programs move from the services to Special Operations Command (SOCOM) and become part of the SOF Major Force Program (MFP 11).
Defense Environmental Restoration Fund	Environmental funds move from service O&M accounts to service environmental appropriation accounts.
Drug Interdiction	Service Drug Interdiction O&M and Non-O&M funding is transferred to OSD as O&M funding.
Military Retired Pay Accrual	Centrally funded military retirement costs move into the individual military pay appropriations in each program element.
Real Property Maintenance Activities (RPM)	Special RPM appropriations for FY92–93 are returned to O&M.
Airlift Operations	Military personnel costs for (RPM) Airlift Operations funded from O&M return to the Military Personnel appropriation.

[a] DoD recently changed the term DBOF, used through this paper, to Defense Working Capital Funds (DWCF).

Table A-2. Effect of Policy Changes on DoD O&M Accounts for the FY 1975–95 Period (FY 1997 Constant Dollars In Billions)

Funding Policy Change	Total DoD O&M	Customer Account O&M	Central Account O&M	Total Service O&M	Total Agency O&M
Supply	2.5	85.9	-83.3	25.4	-22.9
Contract Management	—	—	—	-10.4	10.4
Commissary Operations	-10.5	—	-10.5	-10.5	—
Subsistence-in-Kind	-4.3	—	-4.3	-4.3	—
Spares	63.5	115.5	-52.0	63.5	—
Equipment Modification Installation	-26.8	-11.6	-15.2	-26.8	—
Air Force Depot Maintenance	—	39.1	-39.1	—	—
First Destination Transportation	-2.2	—	-2.2	-2.2	—
Medical Programs	5.1	—	5.1	-78.2	83.3
Special Operations Forces	—	—	—	-2.2	2.2
Defense Environmental Restoration Fund	—	—	—	—	—
Drug Interdiction	1.2	—	1.2	-0.7	2.0
Military Retired Pay Accrual	—	—	—	—	—
Real Property Maintenance Activities	—	—	—	2.3	-2.3
Airlift Operations	-3.7	—	-3.7	-3.7	—
Net Impact	24.8	228.8	-204.0	-47.8	72.6

More detailed explanations of the figures in Table A-2 follow:

- ***Total DoD O&M Column.*** This column shows how much funding has migrated in and out of the overall O&M budget title. For example, in the Supply row, $2.5 billion moved into O&M from the Procurement accounts.
- ***Customer and Central Account O&M Columns.*** These columns show funds transferred between the central accounts and the customer accounts. Again, on the Supply row, $83.3 billion left the central accounts to appear in customer accounts as $85.9 billion. The extra $2.5 billion is the funding that migrated into O&M from the Procurement accounts.
- ***Total Service and Agency O&M Columns.*** These columns show funds transferred between service budgets and defense agency budgets. On the Supply row, $22.9 billion left the agency budgets to appear in the service budgets as $25.4 billion. Again, the extra $2.5 billion migrated into O&M from the Procurement accounts.

APPENDIX B

DEFENSE MISSION CATEGORIES

Table B-1. Major Force Missions

DMC	Mission Category Title
1	Major Force Missions
11	Strategic Forces
111	Strategic Offense
1111	Bomber Forces
11111	Bombers
11112	Tankers
1112	ICBMs
1113	SLBMs
11131	SLBM Forces
11132	SLBM BOS & Mgmnt. HQs
1114	Actys Supporting Bombers & ICBMs
11141	USAF Strategic Support Activities
11142	USAF Strategic BOS & Mgmnt. HQs
112	Strategic Defense
1121	Space Defense
1122	Ballistic Missile Defense
11221	Ballistic Missile Defense Forces
11222	Missile Defense BOS & Mgmnt. HQs
1123	Interceptors
1124	NORAD/SPACECOM Support
11241	NORAD/SPACECOM Support Activities
11242	NORAD/SPACECOM BOS & Mgmnt. HQs
1125	Surveillance
1126	Air Defense Initiative
113	Strategic C3
1131	Surveillance/Warning
1132	Command Centers
1133	Communications
114	Industrial & Stock Fund Support
12	General Purpose Forces

(Continued on the next page.)

Table B-1—*Continued*

DMC	Mission Category Title
121	Land Forces
1211	Army Division Increment
1212	Army Non-Divisional Combat Increment
1213	Army Tactical Support Increment
1214	Marine Ground Forces
12141	Marine Divisions
12142	Marine Non-Divisional Combat Increment
12143	Marine Tactical Support Increment
1215	Army Special Mission Forces
1216	Army BOS & Mgmnt. HQs
1217	Army Operational Support
1218	Army R&D Support
12181	Army Aircraft R&D Programs
12182	Army Missile R&D Programs
12183	Army Weapons & Tracked Combat Veh. R&D
12184	Army Ammunition R&D Programs
12185	Army Other R&D Programs
1219	Army Systems Support
121A	Marine Ground Forces Support
121A1	Marine BOS & Mgmnt. HQs
121A2	Marine Operational Support
121A3	Marine R&D Support
121B	Non-Strategic Nuclear Land Forces
122	Tactical Air Forces
1221	Air Force
12211	Air-To-Air Combat
12212	Air-To-Ground Combat
12213	Defense Suppression
12214	Tactical Reconnaissance
12215	Tactical C3
12216	Tanker/Cargo
12217	Other Tactical Air Warfare
12218	Non-Strategic Nuclear TacAir Forces
12219	R&D Support To Tactical Air Forces
1221A	Operations Support TacAir Activities
1221B	Operations Support BOS & Mgmnt. HQs
1222	Marine

(Continued on the next page.)

Table B-1—*Continued*

DMC	Mission Category Title
12221	Air-To-Air Combat
12222	Air-to-Ground Combat
12223	Defense Suppression
12224	Tactical Reconnaissance
12225	Tactical C3
12226	Tanker/Cargo
12227	Other Tactical Air Warfare
12229	R&D Support to Tactical Air Forces
1222A	Operations Support TacAir Activities
1223	Navy
12231	Air-To-Air Combat
12232	Air-to-Ground Combat
12233	Defense Suppression
12234	Tactical Reconnaissance
12235	Tactical C3
12237	Other Tactical Air Warfare
123	Naval Forces
1231	Submarines
1232	Surface Combatants
12321	Carriers
12322	Battleships
12323	Cruisers & Destroyers
12324	Frigates, Patrol Combatants, & Craft
1233	Amphibious Forces
1234	Service Forces
1235	Mine Warfare Forces
1236	Maritime Patrol & Undersea Surveillance
12361	Maritime Patrol
12362	Undersea Surveillance
1237	Sea Based ASW Air Forces
1238	Non-Strategic Nuclear Naval Forces
1239	Fleet Support
12391	Fleet Support, General
12392	Fleet Support, Surface
12393	Fleet Support, Air
123A	Navy Systems Support
123A1	Navy Systems Support, General
123A2	Navy Systems Support, Surface

(Continued on the next page.)

Table B-1—*Continued*

DMC	Mission Category Title
123A3	Navy Systems Support, Surface and Air
123A4	Navy Systems Support, Air
123B	Navy R&D Support
123B1	Navy Surface Ship Related R&D
123B2	Navy Aircraft Related R&D
123B3	Navy General R&D Support
123C	Navy BOS & Mgmnt. HQs
123C1	Navy BOS & Mgmnt. HQs, General
123C2	Navy BOS & Mgmnt. HQs, Surface
123C3	Navy BOS & Mgmnt. HQs, Subsurface
123C4	Navy BOS & Mgmnt. HQs, Air
123C5	Navy BOS & Mgmnt. HQs, Projection
123D	Other Operational Support
123D1	Other Operational Support, General
123D2	Other Operational Support, Surface
123D3	Other Operational Support, Subsurface
123D4	Other Operational Support, Air
123D5	Other Operational Support, Projection
124	Mobility Forces
1241	Multimode & Intermodal Lift
12411	Multi/Intermodal C3
12413	Multi/Intermodal Intertheater Transport
12418	Multi/Intermodal BOS & Mgmnt. HQs
1242	Airlift Forces
12421	Airlift C3
12423	Military Intertheater Airlift
12424	Aeromedical Airlift
12425	Commercial Airlift
12426	Military Intratheater Airlift
12427	Airlift Rescue & Recovery
12428	Airlift BOS & Mgmnt. HQs
12429	Airlift Operational Support
1242A	Airlift Revenues
1243	Sealift Forces
12431	Sealift C3
12432	Sea Based Prepositioning
1243	Military Intertheater Sealift
12435	Commercial Sealift
12438	Sealift BOS & Mgmnt. HQs

(Continued on the next page.)

Table B-1—*Continued*

DMC	Mission Category Title
1243A	Sealift Revenues
1244	Land Mobility Forces
12441	Land Mobility C3
12442	Land Based Prepositioning
12443	Military Intratheater Land Mobility
12448	Land Mobility BOS & Mgmnt. HQs
12449	Land Mobility Operational Support
1244A	Land Mobility Revenues
125	Special Operations Forces
1251	SOF Operations
1252	SOF Support Activities
12521	SOF Training
12522	SOF General Support
12523	SOF Force Enhancements
12524	Advanced Special Operations RD&A
12525	SOF BOS & Mgmnt. HQs
126	General Purpose Support
127	Theater Missile Defense
128	Counterdrug Support

Table B-2. Defense-Wide Missions

DMC	Mission Category Title
2	Defense-Wide Missions
21	Intell, Comm, C2, & Information Mgt
211	Defense-Wide Intelligence
2111	National Foreign Intelligence Program
21111	Consolidated Cryptologic Program (CCP)
21112	General Defense Intelligence Prgm (GDIP)
21113	Special Activities, Navy
21114	National Reconnaissance Program (NRP)
21115	National, Selected, and Fed Activities
21116	Foreign Counterintelligence Prgm (FCIP)
21117	Central Imagery Office Program (CIOP)
2112	Joint Military Intell Program (Partial)
21121	Defense Crytologic Program (DCP)
21122	Defense Imagery Program (DIP)
21123	Def Mapping, Charting, Geodesy Program
21124	Defense Intelligence Tactical Program
21125	Def Intell Spec Technology Program
21126	Def Airborne Reconnaissance Program
21127	Def Space Reconnaissance Program
21128	Def Intelligence Counterdrug Program
2113	Intelligence & Related Activities
212	Communications
2121	Centrally Managed Communications
21211	Centrally Managed Comm. Activities
21212	Communications BOS & Mgmnt. HQs
2122	Satellite Communications
213	Command & Control
214	Information Management
22	General Research & Development
221	Science & Technology Program
2211	Technology Base
22111	Basic Research (6.1)
22112	Exploratory Development (6.2)
2212	Advanced Development
222	Undistributed Dem/Val, EMD Programs
2221	Undistributed Dem/Val Programs
2222	Undistributed EMD Programs
223	RDT&E Management & Support
2231	R&D Support Activities
2232	R&D BOS & Mgmnt. HQs
23	Other Defense-Wide Missions

(Continued on the next page.)

Table B-2—*Continued*

DMC	Mission Category Title
231	Geophysical Sciences
2311	Geophysical Activities
2312	Geophysical BOS & Mgmnt. HQs
232	Space Launch Support
233	Nuclear Weapons Support
234	International Support
235	Security & Investigative Functions

Table B-3. Defense-Wide Support Missions

DMC	Mission Category Title
3	Defense-Wide Support Missions
31	Logistics Support
311	Supply Operations
312	Maintenance Operations
313	Other Logistics Support
3131	Logistics Support to R&D Activities
3132	Logistics Support to Procurement Acts
3133	Logistics Support to MILCON Activities
3134	Logistics BOS & Mgmnt. HQs
3135	Other Logistics Support
32	Personnel Support
321	Personnel Acquisition
3211	Personnel Acquisition
3212	Personnel Acquisition Base Operations
322	Training
3221	Military Personnel Training
3222	Civilian Personnel Training
3223	Flight Training
3224	Intelligence Skill Training
3225	Health Personnel Training
3226	Training BOS & Mgmnt. HQs
323	Medical
3231	Hospitals & Other Medical Activities
3232	Medical BOS & Mgmnt. HQs
324	Individuals
325	Federal Agency Support
326	Other Personnel Support
3261	Family Housing
3262	Dependent Education
3263	Other Personnel Support Activities
3264	Personnel BOS & Mgmnt. HQs
33	Other Centralized Support
331	Departmental
3311	Departmental Services
3312	Departmental BOS & Mgmnt. HQs
332	Retired Pay
333	Undistributed Adjustments

ABBREVIATIONS

CBSX	Continued-Balance System Extended
CV	Carrier
CVN	Nuclear Carrier
DBOF	Defense Business Operations Fund
DLRs	depot-level reparables
DMC	Defense Mission Category
ECP	Engineering Change Proposal
FY	fiscal year
FYDP	Future Years Defense Program
IFV	Infantry Fighting Vehicle
MFP	Major Force Program
MOEs	measures of effectiveness
O&M	Operations and Maintenance
O&S	operating and support
OPTEMPO	operating tempo
OSMIS	Operating and Support Management Information System
PAA	Primary Aircraft Authorization
SASDT	Ships and Aircraft Supplemental Data Tables
SLBM	submarine-launched ballistic missile
TASC	The Analytic Sciences Corporation
TASCFORM	Technique for Assessing Comparative Force Modernization
VAMOSC	Visibility and Management of Operating and Support Costs
VLS	Vertical Launch System

UNCLASSIFIED

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1997	Final Report, Jul 95–Oct 1997

4. TITLE AND SUBTITLE
"Trends in Weapon System Operating and Support Costs"

5. FUNDING NUMBERS
DASW01 94 C 0054

T-G7-838

6. AUTHOR(S)
Timothy J. Graves, Jospeh S. Domin, and Ronald E. Porten

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Paper P-3313

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Mr. Stanley Azebu
Acquisition Resources, Acquisition Program Integration
OUSD(A&T)
Room 1E474, The Pentagon
Washington, DC 20301-3000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12A. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12B. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

In this period of diminishing Department of Defense budgets, an increasing percentage of each budget goes to the operating and support (O&S) accounts. This slows modernization of weapon inventories and could cause the average age of weapon systems in use to rise, perhaps to unacceptable levels. To address this situation, decision makers must find ways to lower the O&S costs of existing and future systems. This study was to determine if past efforts to reduce O&S costs have been effective. DoD's efforts to reduce per unit weapon system O&S costs have not been fully successful. In half of the cases we studied, new weapons were more expensive to operate, and in the other half they were the same or less expensive. However, most new weapon systems are more complex, more expensive to buy, and have significantly more capability than their predecessors. When you take asset value and capability into account, new systems are often less expensive to operate than the systems they replaced. The study does not address potential O&S cost increases avoided through cost-reducing design initiatives.

14. SUBJECT TERMS
Military Budgets, Operating and Support (O&S) Costs, Weapon Systems

15. NUMBER OF PAGES
114

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR